01 SOLID FUELS

Sources, winning, properties

10/01494 Evaluating the gas content of coals and isolated maceral concentrates from the Paleocene Guasare Coalfield, Venezuela

Berbesi, L. A. *et al. Applied Geochemistry*, 2009, 24, (10), 1817–1824.

This work presents the results from evaluating the gases sorbed by coal samples extracted from the Paleocene Guasare Coalfield (Marcelina Formation, northwestern Venezuela), as well as by their distinct maceral concentrates. The aim of this work was to obtain an initial experimental main value of the gas content per unit weight of high volatile bituminous A coal samples from the open-pit Paso Diablo mine. An additional goal was to study differences in the CH_4 storage ability of the distinct maceral groups forming part of the coal matrix. Both the coal samples and the maceral concentrates were studied by thermogravimetric analysis (TGA) in order to determine the temperature to be used in subsequent experiments. On-line analyses of hydrocarbons (C_1, C_2, C_3) and CO_2 yielded gas concentrations, plus $\delta^{13}C$ values. Thermogenic gas is prevalent in the Guasare coals with vitrinite reflectance ($\%R_o$) values from 0.65% to 0.88%. The amount of gas retained in the coals and maceral concentrates was measured with a special device that allows determination of the volume of gas sorbed by a solid sample subjected to controlled thermal treatment. The average coalbed gas concentration obtained was $0.51\,cm^3/g$. The following list of maceral concentrates shows the relative capacity for the volume of sorbed gas per unit weight: inertinite $>$ low-density vitrinite $>$ liptinite $\approx$ high-density vitrinite. It is concluded that the gas volumes retained in the distinct maceral concentrates are not controlled by porosity but rather by their microscopic morphology.

10/01495 Molecular representations of Permian-aged vitrinite-rich and inertinite-rich South African coals

Van Niekerk, D. and Mathews, J. P. *Fuel*, 2010, 89, (1), 73–82.

Molecular representations for two Permian-aged South African coals, inertinite-rich Highveld (dominated by semifusinite) and vitrinite-rich Waterberg were constructed based on analytical data. High-resolution transmission electron microscopy (HRTEM) was used to determine the size and distribution of aromatic fringes, thereby affording the base aromatic skeleton for each coal model. Sulfur, nitrogen, oxygen and aliphatic side chains and crosslinks were added to the aromatic skeletons according to ^{13}C NMR and literature data. The individual molecules were assembled into three-dimensional structures and were in agreement with experimental data (NMR, mass spectrometry and elemental analyses data). These models were structurally diverse with a molecular weight ranging from 78 to 1900 amu. The vitrinite-rich coal model consists of 18,572 atoms and 191 individual molecules and the inertinite-rich coal model consists of 14,242 atoms and 158 individual molecules. These were the first molecular representations for South African vitrinite-rich and inertinite-rich coals. The inertinite-rich Highveld coal model was more aromatic with a larger portion of the aromatic carbons polycondensed. The vitrinite-rich Waterberg coal model was more aliphatic and contained more aliphatic side chains and longer aliphatic crosslinks. Although these coals have very similar average molecular structures according to the various analytical data, subtle differences in the experimental data lead to significant structural differences in the models.

10/01496 Numerical investigation on the combustion behaviour of pre-dried Greek lignite

Agraniotis, M. *et al. Fuel*, 2009, 88, (12), 2385–2391.

Dry coal firing is expected to play an increasingly important role in future lignite power plants. The planned evolution from the conventional lignite drying concept with hot recirculated flue gas to the ‘fluidized bed drying with internal heat utilization, WTA’, technology in the next generation of lignite power plants is estimated to bring an additional efficiency increase of 2–4% points compared to the today's state of the art. In this framework NTUA/LSB and CERTH/ISFTA has performed experimental investigations at a semi industrial scale 1 MWth facility on the characterization of Greek pre-dried lignite's combustion behaviour in terms of temperature fields, heat transfer, emissions, slagging and fouling tendency and residues quality. The present work focuses on the numerical investigation of Greek dry lignite combustion firstly by post-processing and evaluation of available experimental data and secondly by combustion simulations. Q–T plots describing the heat transfer in the experimental facility are derived and specific cases of the performed tests are simulated with a commercial CFD tool, in order to estimate flow, temperature fields, NO_x emissions and compare with the available experimental data. A good agreement between simulated and experimental results will support the further work on large scale boiler simulations in raw and dry coal co-firing mode, where the possibility of validation with experimental data is limited. The obtained Q–T diagrams are used to evaluate the influence of co-firing on the heat transfer in the facility and to further extrapolate the conclusions of the performed semi industrial tests on the large scale. The overall results of the CFD simulations, including predictions of temperature and NO_x profiles, are in good agreement with the available experimental data at the reference case, while at the dry coal co-firing cases succeed on reproducing the basic trends of the performed experiments.

10/01497 Solvent swelling behavior of Permian-aged South African vitrinite-rich and inertinite-rich coals

Van Niekerk, D. *et al. Fuel*, 2010, 89, (1), 19–25.

Two South African coals similar in rank and age, but different in maceral composition, were studied using solvent swelling. Inertinite-rich Highveld coal (dominated by semifusinite) and vitrinite-rich Waterberg coal were evaluated for swelling extent and swelling rate using N-methylpyrrolidone (NMP) and CS_2/NMP. A stop-motion videography method was developed to study individual particle swelling behaviour. This method allowed observation of overshoot and climbing-type swelling, as well as swelling kinetics. Single-particle swelling experiments showed that both coals exhibited overshoot-type and climbing-type swelling. The inertinite-rich coal swelled much faster (in both solvents) than the vitrinite-rich coal. The swelling in CS_2/NMP was faster for both coals. Kinetic parameters showed that solvent swelling was governed by relaxation (super-Case II relaxation) of the coal structure. X-ray computed tomography was conducted over a 50 h swelling period in NMP for single particles of each coal. Anisotropic swelling was observed in all the particles (swelling greater perpendicular to the bedding plane than parallel to it). The subtle changes in molecular structure, fine structural and physical differences resulted in significant differences in solvent swelling behaviour.

Preparation

10/01498 A predictive multi-step kinetic model of coal devolatilization

Sommariva, S. *et al. Fuel*, 2010, 89, (2), 318–328.

Devolatilization is the first step in coal combustion and gasification, thus an accurate kinetic modelling is relevant for the optimal design of these processes. In this work a relatively simple but flexible kinetic model is used to predict the thermal degradation of different coals in a wide range of operating conditions. The main feature of the model lies in its predictive capability: the elemental composition of the starting coal and the operating conditions are the only information required. Three reference coals are used to characterize the devolatilization process. The pyrolysis of each reference coal is described with a multi-step kinetic mechanism effective both at high and low heating rates. The devolatilization of the actual coal is simply obtained as a linear combination of the thermal degradation of the reference coals. The complete kinetic model refers to 30 reactions and lumped species, which makes this scheme suitable for being adopted in fluidynamic computations. A wide collection of comparisons between model prediction and experimental data validates this model both in terms of residual char and in terms of detailed gas and tar composition. The importance of secondary gas-phase reactions, mainly at high pressure, is also discussed and verified on the basis of an existing detailed kinetic scheme of pyrolysis and oxidation of hydrocarbon fuels.

10/01499 Hydrogen-fueled internal combustion engines

Verhelst, S. and Wallner, T. *Progress in Energy and Combustion Science*, 2009, 35, (6), 490–527.

The threat posed by climate change and the striving for security of energy supply are issues high on the political agenda these days. Governments are putting strategic plans in motion to decrease primary energy use, take carbon out of fuels and facilitate modal shifts. Taking a prominent place in these strategic plans is hydrogen as a future energy carrier. A number of manufacturers are now leasing demonstration vehicles to consumers using hydrogen-fuelled internal combustion engines (H_2ICEs) as well as fuel cell vehicles. Developing countries in particular are pushing for H_2ICEs (powering two- and three-wheelers as well as passenger cars and buses) to decrease local pollution at an affordable cost. This article offers a comprehensive overview of H_2ICEs. Topics that are discussed include fundamentals of the combustion of hydrogen, details on the different mixture formation strategies and their emissions characteristics, measures to convert existing vehicles, dedicated hydrogen engine features, a state of the art on increasing power output and efficiency while controlling emissions and modelling.

Transport, storage

10/01500 Characterization of pneumatic transportation of pulverised coal in a horizontal pipeline through measurement and computational modelling

Chinnayya, A. *et al. Fuel*, 2009, 88, (12), 2348–2356.

Pneumatic conveyors which feed the burners at coal-fired power plants are not designed for the injection of an increasingly wide variety of modern fuels. The objective of this study was to understand and predict the stable delivery of fuel to the burners. The pneumatic transportation of pulverized coal in a horizontal pipeline was investigated using a classic dual approach: measuring a set of characteristic parameters of the dispersed flow as well as its computational modelling. The large eddy simulation approach is used for the modelling of the air/fuel two-phase flow. A particular treatment for the solid phase has been designed in order to cope with gravity effects. A good qualitative agreement between the modelling results and the experimental data was found. The importance of gravity effects compared to inter-particle collisions is addressed.

Economics, business, marketing, policy

10/01501 Coal consumption and economic growth revisited

Wolde-Rufael, Y. *Applied Energy*, 2010, 87, (1), 160–167.

This paper revisits the causal relationship between coal consumption and real GDP for six major coal-consuming countries for the period 1965–2005 within a vector autoregressive (VAR) framework by including capital and labour as additional variables. Applying a modified version of the Granger causality test due to Toda and Yamamoto, a unidirectional causality running from coal consumption to economic growth in India and Japan was found while the opposite causality running from economic growth to coal consumption was found in China and South Korea. In contrast there was a bi-directional causality running between economic growth and coal consumption in South Africa and the United States. Variance decomposition analysis seems to confirm the Granger causality results. The policy implication is that measures adopted to mitigate the adverse effects of coal consumption may be taken without harming economic growth in China and South Korea. In contrast, for the remaining four countries conservation measures can harm economic growth.

10/01502 Coal restructuring in Spain: continuity and uncertainty?

Rabanal, N. G. *Energy Policy*, 2009, 37, (11), 4373–4378.

The policies of coal energy are currently undergoing a significant change. At the European Community level, energy concerns are dominated by environmental commitments that seem to demand coal's disappearance. The countries that for years have supplied the European energy market with this resource have confronted their future challenges in differing ways. The history of the energy sector in Spain has been marked by important changes, and coal has been a key factor in this process. Membership in the European Union has constituted a clear transition for a historically subsidized and protected sector that now faces an uncertain role in the national energy market. The aim of this paper is to offer an overview and analysis of the mechanisms that have been implemented in the energy sector. The first part analyses the rationalization policies that preceded Spanish entry into the EU, giving a detailed description of the complex programs designed by the government to help mining companies. The second part analyses later systems aimed at helping the coal industry that were implemented after the EU imposed new criteria and objectives. These systems led to the so-called 'mixed model' of rationalization. This model, which is completely different from that implemented in other member states, is based on maintaining a system of subsidies that discriminate between public and private companies. The third part examines the objectives of the current system and the plans projected for the future in the context of the EU's adoption of an energy strategy that seeks to reconcile a self-sufficient energy supply with adherence to environmental commitments.

10/01503 Development of an inexact optimization model for coupled coal and power management in North China

Liu, Y. *et al. Energy Policy*, 2009, 37, (11), 4345–4363.

In this study, an inexact coupled coal and power management (ICCPM) model was developed for planning coupled coal and power management systems through integrating chance-constrained programming (CCP), interval linear programming (ILP) and mixed integer linear programming (MILP) techniques. The ICCPM model can effectively handle uncertainties presented in terms of probability density functions and intervals. It can also facilitate dynamic analysis of capacity expansions, facility installation and coal inventory planning within a multi-period and multi-option context. Complexities in coupled coal and power management systems can be systematically reflected in this model, thus applicability of the modelling process would be highly enhanced. The developed ICCPM model was applied to a case of long-term coupled coal and power management systems planning in north China. Interval solutions associated with different risk levels of constraint violations have been obtained, which can be used for generating decision alternatives and helping identify desired policies. The generated results can also provide desired solutions for coal and power generation, capacity initiation and expansion, and coal blending with a minimized system cost, a maximized system reliability and a maximized coal transportation security. Tradeoffs between system costs and constraint-violation risks can also be tackled.

Derived solid fuels

10/01504 Characterization and application of chars produced from pinewood pyrolysis and hydrothermal treatment

Liu, Z. *et al. Fuel*, 2010, 89, (2), 510–514.

Two types of pinewood chars, hydrothermal char (H300) and pyrolytic char (P700) from biomass-to-energy conversion were characterized and used as adsorbent for the copper removal from aqueous solution. The result showed that the pinewood underwent a deeper carbonization during pyrolysis process and more activated sites available and stable carbon–oxygen complex existed after hydrothermal treatment. Comparing with raw pinewood, hydrothermal treatment increased 95% total oxygen-containing groups (carboxylic, lactone and phenolic group) while 56% oxygen-containing groups decreased after pyrolysis process. SEM analysis indicated that both hydrothermal and pyrolytic processes developed rough surface with new cavities on the chars, and the BET surface area were 21 and $29\,m^2/g$ for H300 and P700, respectively. Although H300 had lower surface area, its adsorption capacity for copper was much higher than P700 since ion-exchange reaction was the predominant removal mechanism by H300, while physical adsorption dominated by P700. The adsorption data could be well described by Langmuir isotherm model for copper onto both H300 and P700.

10/01505 Effect of extractives and storage on the pelletizing process of sawdust

Nielsen, N. P. K. *et al. Fuel*, 2010, 89, (1), 94–98.

The importance of extractives and storage for sawdust as raw material for wood pellet production was analysed. Sawdust prepared from eastern white pine (*Pinus strobus* L.), white oak (*Quercus alba* L.) and yellow-poplar (*Liriodendron tulipifera* L.) together with two commercial raw materials were extracted with acetone or stored at 60 °C for 21 days. The effects of the treatments were measured on the pellet strength, and with respect to the energy use requirements of a commercial pellet mill using laboratory dies and methods to measure the different stages of the pelletizing process individually. The results showed that removal of the extractives significantly increased the pellet strength and the energy requirements in all stages of the pelletizing processes corresponding to the samples extractives content, whereas the effect of the storage treatment was indefinite. The study indicates that extractives act as plasticizers and lubricants and thereby decrease the energy requirements for the pelletizing process. On the other hand, extractives seem to prevent close contact between the bonding sites of the lignocellulose particles and thereby decrease the pellet strength. Differences in extractives content can therefore explain differences in pellet mill energy consumption and capacity when raw materials from different wood species are used. The effect of storage with respect to particle surface accumulation of extractives may have little importance compared to the total amount of extractives in the raw material.

10/01506 Enhanced catalysis of K_2CO_3 for steam gasification of coal char by using $Ca(OH)_2$ in char preparation

Wang, J. *et al. Fuel*, 2010, 89, (2), 310–317.

A novel approach has been proposed for mitigating the potassium deactivation in the K_2CO_3-catalysed steam gasification of coal char by addition of $Ca(OH)_2$ in the char preparation. It was experimentally found that the $Ca(OH)_2$-added char had higher reactivity for the catalytic gasification than the raw char. $Ca(OH)_2$ played a role in suppressing the interactions of K_2CO_3 with acidic minerals in coal during the gasification and also probably in forming more active oxygenated intermediate on the char surface. The distribution of gaseous products was examined during the catalytic gasification. An oxygen transfer and intermediate hybrid mechanism is applied for understanding of the rate and selectivity of the catalytic gasification.

10/01507 Growth of single-crystal α-MnO_2 nanotubes prepared by a hydrothermal route and their electrochemical properties

Xiao, W. *et al. Journal of Power Sources*, 2009, 193, (2), 935–938.

Single-crystal α-MnO_2 nanotubes are synthesized by a facile hydrothermal method without the assistance of a template, a surfactant and heat-treatment. The single-crystal α-MnO_2 nanotube electrode possesses a high specific capacitance with a good power capability. The excellent pseudo-capacitive properties are attributed to a nanotubular microstructure and a large tunnel cavity in the α-MnO_2 crystal structure. Single-crystal α-MnO_2 nanotubes with good electrochemical performance can be a promising candidate as supercapacitor materials.

10/01508 Improved and more environmentally friendly charcoal production system using a low-cost retort–kiln (Eco-charcoal)

Adam, J. C. *Renewable Energy*, 2009, 34, (8), 1923–1925.

Research into a low-cost retort–kiln, used to produce charcoal from sustainably managed forests in a more environmentally friendly way (Eco-Charcoal), has been completed and pilot units have been built in India and East Africa. The unit is called ICPS (improved charcoal production system). Importantly, it has a much higher efficiency rating than traditional earth-mound kilns, which have until now been the main means of domestic charcoal production in developing nations. The efficiency of traditional charcoal production methods is about 10%–22% (calculated on using oven-dry wood with 0% water content) while the efficiency of the ICPS is approximately 30%–42%. As compared with traditional carbonization processes, the ICPS reduces emissions to the atmosphere by up to 75%. The ICPS works in two different phases. During the first phase the ICPS works like a traditional kiln; however, waste wood is burned in a separate fire box to dry the wood. During the second phase of operation the harmful volatiles are burned in a hot ‘fire chamber’ meaning all resulting emissions are cleaner, minus these already reduced volatiles. The heat gained by flaring the wood gazes, is used and recycled to accelerate the carbonization process. Unlike traditional methods the ICPS can complete a carbonization cycle within 12 h.

10/01509 Modeling climate change mitigation from alternative methods of charcoal production in Kenya

Bailis, R. *et al. Biomass and Bioenergy*, 2009, 33, (11), 1491–1502.

Current carbon accounting methodologies do not accommodate activities that involve emissions reductions from both land-use change and energy production. This paper analyses the climate change mitigation potential of charcoal production in East Africa by examining the impact of changing both land management and technology. Current production in a major charcoal-producing region of Kenya where charcoal is made as a by-product of land clearance for commercial grain production is modelled as the ‘business-as-usual’ scenario. Alternative production systems are proposed based on coppice management of native or exotic trees. Improved kilns are also considered. Changes in aboveground, belowground, and soil carbon are modelled and two distinct baseline assessments are analysed: one is based on a fixed area of land and one is based on the quantity of non-renewable fuel that is displaced by project activities. The magnitude of carbon emissions reductions varies depending on land management as well as the choice of carbonization technology. However, these variations are smaller than the variations arising from the choice of baseline methodology. The fixed-land baseline yields annualized carbon emission reductions equivalent to 0.5–2.8 tons per year ($t\,y^{-1}$) with no change in production technology and 0.7–3.5 $t\,y^{-1}$ with improved kilns. In contrast, the baseline defined by the quantity of displaced non-renewable fuel is 2–6 times larger, yielding carbon emissions reductions of 1.4–12.9 $t\,y^{-1}$ with no change in production technology and 3.2–20.4 $t\,y^{-1}$ with improved kilns. The results demonstrate the choice of baseline, often a political rather than scientific decision, is critical in assessing carbon emissions reductions.

02 LIQUID FUELS

Sources, properties, recovery

10/01510 Autoregressive modeling of near-IR spectra and MLR to predict RON values of gasolines

Kardamakis, A. A. and Pasadakis, N. *Fuel*, 2010, 89, (1), 158–161.

A new calibration method that accurately predicts the research octane number (RON) values of gasoline fractions, based on their infrared spectra, is presented. This model combines linear predictive coding (LPC) and multiple linear regression (MLR) as an integrated estimation technique. Spectral information from the 4800–3520 cm^{-1} range was initially encoded into linear predictive (LP) coefficients, which were used as predictor variables in the MLR model against RON values. The model was trained and tested on an extensive data set (384 gasoline samples) and found to ensure prediction accuracy of 0.3 RON root mean squared error (RMSE). The LPC technique was found to be efficient in capturing spectral features of the entire range, related to the RON characteristics of the gasoline samples, without the need of any pretreatment on the experimental raw data. The small number of input variables in the regression model ensures a robust, easy-to-use and high accuracy prediction model.

10/01511 Co-current combustion of oil shale – Part 1: characterization of the solid and gaseous products

Martins, M. F. *et al. Fuel*, 2010, 89, (1), 144–151.

Co-current combustion front propagation in a bed of crushed oil shale (OS) leads to the production of liquid oil, of a flue gas and of a solid residue. The objective of this paper was to provide a detailed chemical characterization of Timahdit oil shale and of its smoldering combustion products. The amount of fixed carbon (FC) formed during devolatilization is measured at 4.7% of the initial mass of oil shale whatever the heating rate in the range 50–900 $K\,min^{-1}$. The combustion of oil shale was operated using a mix of 75/25 wt. of OS/sand with an air supply of 1460 $l\,min^{-1}\,m^{-2}$. In these conditions, not all the FC is oxidized at the passage of the front, but 88% only, with a partitioning of 56.5% into CO and the rest into CO_2. A calorific gas with a lower calorific value of 54 $kJ\,mol^{-1}$ is produced. Approximately 52% of the organic matter from OS is recovered as liquid oil. The front decarbonates 83% of carbonates.

10/01512 Co-current combustion of oil shale – Part 2: structure of the combustion front

Martins, M. F. *et al. Fuel*, 2010, 89, (1), 133–143.

Timahdit oil shale was used as a porous medium to characterize the structure of a combustion front propagating with co-current downward air supply. A new 1D experimental device was first calibrated using a model porous medium. With the model porous medium, the front propagates as a plane and horizontal surface while using oil shale the front propagates as an inclined curved surface. The peak temperature was 1100 °C; despite the relatively large diameter of the cell (91 mm) and the good thermal insulation, the heat losses were estimated at 42% of the heat released by the combustion. The thickness of the front was characterized using a new gas micro-sampling system: the char oxidation and the carbonate decarbonation zones are approximately 10 and 15 mm thick, respectively. The oil formed during the pyrolysis is adsorbed in the porous medium in the course of the experiment, and expulsed from the cell by the end.

10/01513 Determination of Algerian Hassi-Messaoud asphaltene aromaticity with different solid-state NMR sequences

Bouhadda, Y. *et al. Fuel*, 2010, 89, (2), 522–526.

An asphaltene fraction derived from an Algerian oil-well was characterized by different MAS/NMR sequences to investigate asphaltene aromaticity and the best cross-polarization contact time. The aromaticity was estimated by single pulse sequence (SP), Hahn-echo (HE), cross-polarization (CP) and variable cross-polarization (VACP) sequences. The values found ranging from 0.58 to 0.48 are of the same order of magnitude as ones published in the literature. The discrepancies between the values are thought to be relevant to both the specificity of each sequence and the asphaltene structure. Spectra band de-convolution enables us the determination of the average number of carbon atoms per side chain according to each sequence. The obtained values spanning from 3 to 7 are also sequence nature dependent.

10/01514 Development of methods to collect and analyze gasoline range (C_5–C_{12}) hydrocarbons from seabed sediments as indicators of subsurface hydrocarbon generation and entrapment

Abrams, M. A. *et al. Applied Geochemistry*, 2009, 24, (10), 1951–1970.

Gasoline range hydrocarbons (C_5–C_{12}) are usually associated with petroleum generation, yet few surface geochemical surveys have attempted to evaluate the gasoline range hydrocarbons in near-surface marine sediments. This is due to the difficulty in capturing and analysing this volatile range of hydrocarbons with minimum loss and evaporative fractionation. In this study, a headspace solid phase microextraction (HSPME) method was developed and evaluated for the purpose of capturing the gasoline range of hydrocarbons within unconsolidated sediment using a solventless protocol. The sediment SPME extraction method is based on the condition that phase/composition equilibrium is reached between sediment/water mix, container headspace, and SPME fibre coated with sorbent. In the experiments, the effectiveness of SPME to detect and measure low concentrations of migrated crude oil in marine sediments was evaluated. The following optimum laboratory procedure for SPME gasoline monitoring was established: collect the sample in sealed disrupter chamber (sealed sediment storage container which breaks apart sediment and releases interstitial volatile hydrocarbons), use a water bath to keep a stable laboratory temperature, use an NaCl saturated solution to help aromatic compounds move out of the solution to vapour phase, and wait a sufficient time to reach equilibrium. The results show that HSPME is very sensitive with sub ppm detection limits. SPME proved to be suitable to reveal the natural background and micro-seepage level of gasoline hydrocarbons in marine sediments.

10/01515 Insights relating to the autoignition characteristics of alcohol fuels

Yates, A. *et al. Fuel*, 2010, 89, (1), 83–93.

A detailed chemical kinetic modelling study was undertaken to characterize the auto-ignition behaviour of a full range of blends of both methanol and ethanol with a PRF 80 base fuel. The overall results were encapsulated in a computationally efficient semi-empirical formulation. The auto-ignition model was combined with an ASTM (CFR) engine simulation to explore the underlying causes for the octane number value exhibited by alcohol fuels. The model predictions were validated against experimental pressure traces obtained with a range of alcohol-PRF blends. These results confirmed the model's general validity and provide valuable insights relating to the controlling role of the cool flame in the octane number determination and the use of alcohol fuels as octane blending components for use in modern and future gasoline engine technologies.

10/01516 Palynology and petroleum potential of the Kazhdumi Formation (Cretaceous: Albian–Cenomanian) in the South Pars field, northern Persian Gulf

Ghasemi-Nejad, E. *et al. Marine and Petroleum Geology*, 2009, 26, (6), 805–816.

The Kazhdumi Formation of the Bangestan Group is a well-known source rock that has produced abundant oil in most petroleum fields in the Zagros Basin, which stretches from northwest to southwest Iran over hundreds of kilometres. The formation reaches a thickness of 230 m at the type section in northwest Zagros but thins out to 40–50 m in wells studied from the South Pars giant petroleum field, where it comprises mainly grey shales with occasional intercalations of marls and sandstones. South Pars, best known as the Iranian part of the world's largest non-associated gas field, contains small quantities of oil above and below the Kazhdumi Formation. Palynology has been used to assess the age and palaeoenvironment of the Kazhdumi Formation and to evaluate its petroleum potential. A total of 68 ditch cutting samples recovered from five wells, of which four are oil-prone, have been analysed. An age between late Albian and Cenomanian is established for the formation based on dinoflagellate cyst biostratigraphy, and four palynofacies types have been recognized using the relative proportions of terrestrial elements, marine palynomorphs and amorphous organic matter (AOM). The ratio of terrestrial to marine elements is high in most samples, indicating a nearshore sedimentary environment. Twenty-two samples from the four oil-prone wells were also selected for geochemical analysis using Rock-Eval pyrolysis. Results show that the Kazhdumi Formation at South Pars, in contrast to the Zagros Basin, is gas-prone (predominantly type III kerogen), thermally immature, and poor in terms of hydrocarbon generation. It could not have produced the oil in those oil-prone wells studied.

Transport, refining, quality, storage

10/01517 Analysis of coke precursor on catalyst and study on regeneration of catalyst in upgrading of bio-oil

Guo, X. *et al. Biomass and Bioenergy*, 2009, 33, (10), 1469–1473.

Catalyst HZSM-5 was used in bio-oil catalytic cracking upgrading. The precursor of coke on the catalyst was analysed by means of TGA, FTIR and C13 NMR. Precursors of coke deposited in the pore of the molecular sieve were mainly aromatic hydrocarbon with the boiling point range from 350 °C to 650 °C. Those on the outer surface of the pellet precursor were identified as saturated aliphatic hydrocarbons with the boiling point below 200 °C. The activity of HZSM-5 was studied after regeneration. In terms of yield of organic distillate and formation rate of coke, results showed that catalytic activity change moderately during the first three times of regeneration.

10/01518 Comparison of bulk kinetic parameters for asphaltenes from long-time stored and related fresher-produced crude oils

Lehne, E. *et al. Applied Geochemistry*, 2010, 25, (3), 382–388.

Two investigated long-time stored oils, which were produced in the 1960s, show strong compositional changes compared to fresher oil samples from the same well and production zones. Asphaltenes isolated from stored and fresher-produced oil pairs show highly similar results from open-system pyrolysis. However, asphaltenes from long-time stored oils show higher reactivity compared to those from fresher oils. The study shows that differences exist in kinetic models based on asphaltenes from fresh-produced oil and those based on oil that has undergone long-term storage, and that these differences may impact geological predictions using such models. Factors controlling the chemical differences between stored and fresher asphaltenes are unclear and hard to determine, because of a broad range of factors controlling compositional differences between these oil pairs. The difference in chemical kinetics might be related to chemical storage effects, but different well-site sampling techniques between decades, or even incomplete homogenization of the long-time stored oils in barrels before sampling may also have an impact.

10/01519 Effects of salinity and temperature on drag reduction characteristics of polymers in straight circular pipes

Kamel, A. and Shah, S. N. *Journal of Petroleum Science and Engineering*, 2009, 67, (1–2), 23–33.

It has been nearly 60 years since the tremendous reduction in wall shear stress caused by the addition of small amount of linear macromolecules to a flowing fluid was first discovered. This drag reduction phenomenon corresponds to an increase in pumpability of a fluid by the additive. Therefore the application of this phenomenon can be found in many areas of the oil and gas industry; including well completion, workover, drilling operations, and hydraulic fracturing. The turbulent flow prevails in such operations. The eddy currents and velocity fluctuations in turbulent motion produce increased pressure drops and thus, limit the maximum obtainable fluid flow rate. This results in a problem particularly in hydraulic fracturing where higher flow rates are desired. Employing the commercially available drag reducing fluids can overcome this limitation. Salinity and temperature are among the factors that affect the extent of drag reduction. Other factors include polymer type and concentration, molecular weight and distribution, solvent chemistry, pH, ionic strength, molecular conformation, flow geometry, and degree of mechanical shearing. Despite the widespread use of brine solutions as base fluids in fracturing the deep hot formations, the effects of temperature and salinity on the drag reduction characteristics of polymers have received the least attention. Most studies on drag reduction have considered either water or salt-free base fluids at ambient temperatures. Therefore, the aim of the present study is to experimentally investigate the effects of salinity and temperature on the extent of drag reduction of polymers flowing in straight circular pipes. Two commonly used anionic polyacrylamides; Nalco ASP-700 and ASP-820 are used in this study: ASP-700 is an analog of partially hydrolysed polyacrylamide (PHPA), while ASP-820 is a sulfonate-containing polyacrylamide. A 1/2-in. OD flow loop with a 15-ft straight tubing is used. Flow tests are conducted to determine the optimum concentrations of ASP-700 and ASP-820 polymers. It is found that the optimum concentration for both polymers is 0.07% (vol.). To investigate the effect of temperature, tests are conducted with fresh water at 72, 100 and 130 °F. Additional tests are conducted at ambient temperature and with 2% KCl brine and synthetic sea water to investigate the effect of salinity on drag reduction of ASP-700 and ASP-820. It is found that both polymers are quite effective drag reducers in circular straight pipes. Drag reduction in the range of 30–80% is noticed. Both temperature and salinity have significant effect on their drag reduction characteristics. Due to differences in their composition and potentially molecular weight variances, both polymers show different characteristics in the presence of salt and at elevated temperatures. Within the conditions studied, ASP-700 is found to be better than ASP-820 at providing drag reduction. Correlations to predict drag reduction at either temperature or salinity are developed. These results are presented and discussed in detail.

10/01520 Quality control of gasoline by ^{1}H NMR: aromatics, olefinics, paraffinics, and oxygenated and benzene contents

Kaiser, C. R. *et al. Fuel*, 2010, 89, (1), 99–104.

A simple and fast ^{1}H NMR method, without any pretreatment, was developed for quality control of gasoline. It is based on the average group molecular weight approach and relative-content concept involving aromatics, olefinics and paraffinics, including also ethanol and benzene contents. The ethanol content was evaluated for Brazilian samples, but the method can be easily adapted to any oxygenated compound (e.g. MTBE), and to gasoline from other countries. A total of 22 laboratory prepared gasoline samples (gasoline from Brazilian refineries plus hydrocarbon solvents) and 34 real (i.e. Brazilian gas stations) gasoline samples were tested. The routine quality control carried out through the usual physicochemical analyses reached a level of confidence of 75% and 73% in detecting non-conformity in laboratory and real gasoline samples, respectively. The NMR method was very superior reaching 100% and 97% of confidence, respectively. It was better suited for laboratories with high sample throughput since measurement time is short and only one NMR experiment is needed per sample.

Economics, business, marketing, policy

10/01521 A panel data analysis of the determinants of oil consumption: the case of Australia

Narayan, P. K. and Wong, P. *Applied Energy*, 2009, 86, (12), 2771–2775.

This study examined the determinants of oil consumption for a panel consisting of six Australian States and one territory, namely Queensland, New South Wales, Victoria, Tasmania, South Australia, Western Australia, and the Northern territory, for the period 1985–2006. It was found that oil consumption, oil prices and income were panel cointegrated. The authors estimated long-run elasticities and found that oil prices have had a statistically insignificant impact on oil consumption, while income has had a statistically significant positive effect on oil consumption.

10/01522 A variant of the Hubbert curve for world oil production forecasts

Maggio, G. and Cacciola, G. *Energy Policy*, 2009, 37, (11), 4761–4770.

In recent years, the economic and political aspects of energy problems have prompted many researchers and analysts to focus their attention on the Hubbert peak theory with the aim of forecasting future trends in world oil production. In this paper, a model that attempts to contribute in this regard is presented; it is based on a variant of the well-known Hubbert curve. In addition, the sum of multiple-Hubbert curves (two cycles) is used to provide a better fit for the historical data on oil production [crude and natural gas liquid (NGL)]. Taking into consideration three possible scenarios for oil reserves, this approach allowed us to forecast when peak oil production, referring to crude oil and NGL, should occur. In particular, by assuming a range of 2250–3000 gigabarrels (Gb) for ultimately recoverable conventional oil, these predictions foresee a peak between 2009 and 2021 at 29.3–32.1 Gb/year.

10/01523 An economic assessment of potential ethanol production pathways in Ireland

Deverell, R. *et al. Energy Policy*, 2009, 37, (10), 3993–4002.

An economic assessment was conducted on five biomass-to-ethanol production pathways utilizing the feedstock: wheat, triticale, sugarbeet, miscanthus and straw. The analysis includes the costs and margins for all the stakeholders along the economic chain. This analysis reveals that under current market situations in Ireland, the production of ethanol under the same tax regime as petrol makes it difficult to compete against that fuel, with tax breaks, however, it can compete against petrol. On the other hand, even under favourable tax breaks it will be difficult for indigenously produced ethanol to compete against cheaper sources of imported ethanol. Therefore, the current transport fuel market has no economic reason to consume indigenously produced ethanol made from the indigenously grown feedstock analysed at a price that reflects all the stakeholders' costs. To deliver a significant penetration of indigenous ethanol into the market would require some form of compulsory inclusion or else considerable financial supports to feedstock and ethanol producers.

10/01524 An empirical analysis of petroleum demand for Indonesia: an application of the cointegration approach

Sa'ad, S. *Energy Policy*, 2009, 37, (11), 4391–4396.

This paper uses selection criteria from various models in a bounds testing approach to cointegration to estimate the price and income elasticities of demand for total petroleum products (gasoline and diesel) and gasoline share in total products in Indonesia. The results suggest that both total products and gasoline share estimates are more responsive to changes in income than changes in the real price of petroleum products. These results have important policy implications as they suggest that policy makers may need to use market-based pricing policies and other policies such as public enlightenment in addition to regulations like minimum energy efficiency standards to promote efficiency and conservation and curb the rising consumption of petroleum products in Indonesia.

10/01525 Aviation fuel and future oil production scenarios

Nygren, E. *et al. Energy Policy*, 2009, 37, (10), 4003–4010.

Most aviation fuels are jet fuels originating from crude oil. Crude oil must be refined to be useful and jet fuel is only one of many products that can be derived from crude oil. Jet fuel is extracted from the middle distillates fraction and competes, for example, with the production of diesel. Crude oil is a limited natural resource subject to depletion and several reports indicate that the world's crude oil production is close to the maximum level and that it will start to decrease after reaching this maximum. A post-Kyoto political agenda to reduce oil consumption will have the same effect on aviation fuel production as a natural decline in the crude oil production. On the other hand, it is predicted by the aviation industry that aviation traffic will keep on increasing. The industry has put ambitious goals on increases in fuel efficiency for the aviation fleet. Traffic is predicted to grow by 5% per year to 2026, fuel demand by about 3% per year. At the same time, aviation fuel production is predicted to decrease by several percent each year after the crude oil production peak is reached resulting in a substantial shortage of jet fuel by 2026. The aviation industry will have a hard time replacing this with fuel from other sources, even if air traffic remains at current levels.

10/01526 Comparison of China's oil import risk: results based on portfolio theory and a diversification index approach

Wu, G. *et al. Energy Policy*, 2009, 37, (9), 3557–3565.

In recent years, the international oil price has fluctuated violently, bringing about huge risk for the international oil trade. In fact, the risk of crude oil and petroleum product imports is different because of the different import origins and prices. Which import risk is lower for China? From the perspective of oil supply security, how should China portfolio crude oil and petroleum product imports to minimize its oil import risk? Using portfolio theory and a diversification index approach, this paper compares and analyses the supply, price and transport risks of crude oil and petroleum product imports. The results show that the following: (1) specific risk (diversification risk) and marine transport risk of China's petroleum product imports are lower than that of crude oil imports; (2) the average rate of return of China's petroleum product imports is higher than that of crude oil imports. Moreover, the average import price variance of petroleum product imports is lower than that of crude oil imports. Thus, the systematic risk (price risk) of petroleum products is lower too. Therefore, from the perspective of oil supply security, China should increase petroleum product imports to decrease its oil import risk.

10/01527 Do Americans want ethanol? A comparative contingent-valuation study of willingness to pay for E-10 and E-85

Petrolia, D. R. *et al. Energy Economics*, 2010, 32, (1), 121–128.

A nationwide contingent-valuation survey of consumer preferences for consumer fuel blends E-10 (a blend of 10% ethanol and 90% gasoline for use in standard vehicles) and E-85 (a blend of 85% ethanol and 15% gasoline for use in flex-fuel vehicles) was conducted to estimate willingness to pay (WTP) and identify key characteristics driving demand. Results indicate that overall perceptions of ethanol are positive, but ethanol is not the globally-preferred transportation-energy alternative, even among consumers with a positive WTP. Results indicate also that demand for E-85 is more price inelastic than E-10, with this result driven by consumers with no preference for E-10 but strong preferences for E-85. Finally, results also indicate that those consumers who are unsure about the micro-level benefits of E-85 are nonetheless more inclined to pay a premium.

10/01528 Estimating petroleum products demand elasticities in Nigeria: a multivariate cointegration approach

Iwayemi, A. *et al. Energy Economics*, 2010, 32, (1), 73–85.

This paper formulates and estimates petroleum products demand functions in Nigeria at both aggregative and product level for the period 1977 to 2006 using multivariate cointegration approach. The estimated short and long-run price and income elasticities confirm conventional wisdom that energy consumption responds positively to changes in GDP and negatively to changes in energy price. However, the price and income elasticities of demand varied according to product type. Kerosene and gasoline have relatively high short-run income and price elasticities compared to diesel. Overall, the results show petroleum products to be price and income inelastic.

10/01529 Gasoline demand in Europe: new insights

Pock, M. *Energy Economics*, 2010, 32, (1), 54–62.

This study utilizes a panel data set from 14 European countries over the period 1990–2004 to estimate a dynamic model specification for gasoline demand. Previous studies estimating gasoline consumption per total passenger cars ignore the recent increase in the number of diesel cars in most European countries leading to biased elasticity estimates. Several common dynamic panel estimators were supplied to the small sample. Results showed that specifications neglecting the share of diesel cars overestimate short-run income, price and car ownership elasticities. It appears that the results of standard pooled estimators are more reliable than common IV/GMM estimators applied to this small data set.

10/01530 How reasonable are oil production scenarios from public agencies?

Jakobsson, K. *et al. Energy Policy*, 2009, 37, (11), 4809–4818.

According to the long-term scenarios of the International Energy Agency (IEA) and the US Energy Information Administration (EIA), conventional oil production is expected to grow until at least 2030. EIA has published results from a resource-constrained production model which ostensibly supports such a scenario. The model is here described and analysed in detail. However, it is shown that the model, although sound in principle, has been misapplied due to a confusion of resource categories. A correction of this methodological error reveals that EIA's scenario requires rather extreme and implausible assumptions regarding future global decline rates. This result puts into question the basis for the conclusion that global 'peak oil' would not occur before 2030.

10/01531 International experiences of ethanol as transport fuel: policy implications for India

Pohit, S. *et al. Energy Policy*, 2009, 37, (11), 4540–4548.

The need for biofuels, particularly liquid ones like ethanol and biodiesel, for transport has been felt by most of the countries and their governments have been trying to promote these fuels. Compared to petroleum, the use of biofuels for transport is still quite low in nearly every country. By far the largest production and use is of ethanol in the United States and Brazil, where similar volumes are used – many times higher than in any other country. Even then, ethanol represents less than 3% of transport fuel in USA and a little more than 50% of gasoline demand (by volume) in Brazil. However many countries, including the USA, Canada, several European countries (and the European Union), Australia and Japan including India are considering or have adopted a variety of policies that could result in much higher biofuels use over the next decade. This paper makes an attempt to draw upon the cross-country international experiences of ethanol as transport fuel to suggest policy implications for India.

10/01532 Iraq pushes ahead with new production plans

Anon., *Oil and Energy Trends*, 2009, 34, (12), 3–6.

Iraq is planning to increase its oil output capacity to almost 5 million barrels per day, nearly doubling its existing production capability. However, before these production programmes can go ahead there are issues around the proposed 'hydrocarbons law' as well as border and territorial issues that need to be resolved.

10/01533 Looking ahead: Iraq makes large upstream awards

Anon., *Oil and Energy Trends*, 2010, 35, (1), 13–14.

Iraq has awarded service contracts to a number of international oil companies, which the Oil Ministry say will increase the country's oil production to 12 million barrels per day. However, some Iraqis have claimed that this production target may well be overambitious, stating that some oil companies may have exaggerated their capabilities in order to secure their bids. In addition, issues such as suitable infrastructure and the security situation may also prove to be threats to meeting production targets.

10/01534 Modelling the impact of oil prices on Vietnam's stock prices

Narayan, P. K. and Narayan, S. *Applied Energy*, 2010, 87, (1), 356–361.

The goal of this paper is to model the impact of oil prices on Vietnam's stock prices. The authors used daily data for the period 2000–2008 and included the nominal exchange rate as an additional determinant of stock prices. They found that stock prices, oil prices and nominal exchange rates are cointegrated, and oil prices have a positive and statistically significant impact on stock prices. This result is inconsistent with theoretical expectations. The growth of the Vietnamese stock market was accompanied by rising oil prices. However, the boom of the stock market was marked by increasing foreign portfolio investment inflows which are estimated to have doubled from US$0.9 billion in 2005 to US$1.9 billion in 2006. There was also a change in preferences from holding foreign currencies and domestic bank deposits to stocks local market participants, and there was a rise in leveraged investment in stock as well as investments on behalf of relatives living abroad. It seems that the impact of these internal and domestic factors were more dominant than the oil price rise on the Vietnamese stock market.

10/01535 Oil and the political economy of energy

Matutinović, I. *Energy Policy*, 2009, 37, (11), 4251–4258.

The key issues concerning oil exploitation are still open for discussion: there is no agreement about where we presently stand in the world oil extraction curve, what is its exact shape, and how far can oil price grow before it changes irreversibly the world economy and consumer behaviour. The paper proposes an alternative scenario to the Hubbert's bell-shaped model of oil exploitation, based on more realistic assumptions regarding political agendas in oil-exporting countries and consumer behaviour dynamics in oil-importing countries. Under this scenario, the joint impact of markets and public policy in oil importing countries together with 'resource pragmatism' policy in oil-exporting countries allows for a less steep oil supply curve with a much fatter tail compared to the Hubbert's model.

10/01536 Rebound and disinvestment effects in refined oil consumption and supply resulting from an increase in energy efficiency in the Scottish commercial transport sector

Anson, S. and Turner, K. *Energy Policy*, 2009, 37, (9), 3608–3620.

This study uses an energy–economy–environment computable general equilibrium (CGE) model of the Scottish economy to examine the impacts of an exogenous increase in energy augmenting technological progress in the domestic commercial transport sector on the supply and use of energy. The authors focus their analysis on Scottish refined oil, as the main type of energy input used in commercial transport activity. It was found that a 5% increase in energy efficiency in the commercial transport sector leads to rebound effects in the use of oil-based energy commodities in all time periods, in the target sector and at the economy-wide level. However, the results also suggest that such an efficiency improvement may cause a contraction in capacity in the Scottish refined oil supply sector. This 'disinvestment effect' acts as a constraint on the size of rebound effects. However, the magnitude of rebound effects and presence of the disinvestment effect in the simulations conducted here are sensitive to the specification of key elasticities of substitution in the nested production function for the target sector, particularly the substitutability of energy for non-energy intermediate inputs to production.

10/01537 The impact of Hurricanes Gustav and Ike on offshore oil and gas production in the Gulf of Mexico

Kaiser, M. J. and Yu, Y. *Applied Energy*, 2010, 87, (1), 284–297.

During August and September 2008, Hurricanes Gustav and Ike passed through the Gulf of Mexico and damaged and destroyed a number of offshore oil and gas structures. In the final official government assessment, a total of 60 platforms were destroyed and 31 structures were identified as having extensive damage. The destroyed platforms were responsible for about 1.6% of the oil and 2.5% of the gas produced daily in the Gulf of Mexico and represented approximately 234 million BOE of reserves valued between $4.6 billion and $10.9 billion. Although the number of structures destroyed by Hurricanes Gustav and Ike was half the total destruction from the 2004–2005 hurricane seasons, the authors estimate that the reserves at risk are approximately three times more valuable. Each destroyed structure is unique in its production capacity and damages incurred and are a candidate for redevelopment. The authors review pre-hurricane production and revenue characteristics for the collection of destroyed structures and estimate production at risk. Gas structures are expected to present better economics and redevelopment potential than oil structures, and the authors predict that 198 million BOE, or nearly 95% of reserves-in-place, are likely to be redeveloped. Shut-in production statistics are compared against recent hurricane events and general comments on the factors involved in decision making are presented.

10/01538 The oil stock fluctuations in the United States

Hayat, A. and Narayan, P. K. *Applied Energy*, 2010, 87, (1), 178–184.

The goal of this paper is to examine whether the volatility of the growth in the US oil stocks has changed overtime, and if it has then whether or not this change is real. It was discovered that the growth in volatility of oil stocks has declined overtime. The authors conducted a Monte Carlo simulation exercise to investigate whether this decline is real or an artefact of the growth definition. The findings support the fact that the decline in growth volatility of oil stocks is an artefact of the growth definition. This is because a data generating process having a unit root with drift has a tendency to grow and thereby pulls the variance of growth down with time.

10/01539 The pass through of oil prices into euro area consumer liquid fuel prices in an environment of high and volatile oil prices

Meyler, A. *Energy Economics*, 2009, 31, (6), 867–881.

Crude and refined oil prices have been relatively high and volatile on a sustained basis since 1999. This paper considers the pass through of oil prices into consumer liquid (i.e. petrol, diesel and heating) fuel prices in such an environment. The pass through of oil prices into consumer liquid fuel prices has already been addressed extensively in the literature. Nonetheless much of this literature has either focused on the USA or on a time period when oil prices were relatively stable, or has used monthly data. The main contribution of this paper is a comprehensive combination of many features that have been considered before but rarely jointly. The main findings are listed below. First, as distribution and retailing costs and margins have been broadly stable on average, the modelling of the relationship between consumer prices excluding taxes and upstream prices in raw levels rather than in logarithms has important implications for the stability of estimates of pass through when oil price levels rise significantly. Second, considering spot prices for refined prices improves significantly the fit of the estimated models relative to using crude oil prices. It also results in more economically meaningful results concerning the extent of pass through. Third, oil price pass through occurs quickly, with 90% occurring within three to five weeks. Fourth, using a relatively broad specification allowing for asymmetry in the pass through from upstream to downstream prices, there is little evidence of statistically significant asymmetries. Furthermore, even where asymmetry is found to be statistically significant, it is generally not economically significant. Lastly, these results generally hold across most euro area countries with few exceptions.

Derived liquid fuels

10/01540 Ethanol plant investment using net present value and real options analyses

Schmit, T. M. *et al. Biomass and Bioenergy*, 2009, 33, (10), 1442–1451.

A real options analysis of entry–exit decisions for dry-grind corn ethanol plants is conducted to incorporate the impact of rising volatility in market prices. For a large plant, the estimated gross margins (ethanol price less corn price), in current dollars, that induce entry and exit were 0.35 US$ dm^{-3} and 0.03 US$ dm^{-3}, respectively; nearly 207% (63%) above (below) their respective net present value estimates. Under baseline conditions, a large operating plant would become mothballed at 0.05 US$ dm^{-3} and reactivate if margins rebounded to 0.17 US$ dm^{-3}. Growth in the variability of ethanol margins will lead to delays in new plant investments, as well as exits of currently operating facilities. To the extent that alternative renewable fuel technologies become viable, the model can be easily adapted to estimate and compare the results across alternative bioenergy investments.

10/01541 Kinetics of Shenhua coal liquefaction catalyzed by $SO_4^{2=}/ZrO_2$ solid acid

Shui, H. *et al. Fuel*, 2010, 89, (1), 67–72.

Based on the structural inhomogeneities of coal and intermediate products of coal liquefaction, a new kinetic model was advanced to simulate the Shenhua coal liquefaction catalysed by $SO_4^{2=}/ZrO_2$ solid acid catalyst using kinetic lump method. It was found that coal was hydrocracked to preasphaltene, asphaltene, oil and gas directly, and preasphaltene and asphaltene were further hydrocracked into oil and gas products in coal liquefaction. Certain regressive reactions existed in the process. The liquefaction conversions calculated from the model agreed well with the experimental data for Shenhua coal liquefaction catalysed by $SO_4^{2=}/ZrO_2$ solid acid at the range of experimental conditions, and the activation energies were 69–136 kJ mol^{-1}. There existed obvious regressive reactions at higher liquefaction temperatures. However, besides the regressive transformation of oil and gas to asphaltene at 450 °C liquefaction, there also existed condensation processes of preasphaltene and asphaltene to coke.

10/01542 Production of synthetic gasoline and diesel fuel by alternative processes using natural gas and coal: process simulation and optimization

Sudiro, M. and Bertucco, A. *Energy*, 2009, 34, (12), 2206–2214.

The problem of producing synthetic liquid fuels by alternative routes is addressed. Industrial processes known as gas to liquid (GTL) and coal to liquid (CTL) are considered and compared to a hybrid process presently developed, which combines features of both GTL and CTL. Detailed process models are developed in this study. Based on simulations, it is shown that the fuel produced per unit of feedstock (weight basis, with a productivity of 100 t/h of synthetic fuels) are 66.7% and 32.5% for GTL and CTL, respectively, and that the CO_2 emitted per unit mass of liquid fuel is 0.63 kg CO_2/kg for GTL and 4.66 kg CO_2/kg for CTL. The hybrid process allows the production of 44.4% of fuel and to reduce CO_2 emissions to 2.45 kg CO_2/kg liquid fuel. By using pinch technology analysis (PTA) a heat integration of the hybrid process is carried out. From the results of PTA, no pinch point is found, a considerable amount of cooling water is needed, and the resulting thermal efficiency is around 55%.

03 GASEOUS FUELS

Sources, properties, recovery, treatment

10/01543 Chemical and isotopic tracers of the contribution of microbial gas in Devonian organic-rich shales and reservoir sandstones, northern Appalachian Basin

Osborn, S. G. and McIntosh, J. C. *Applied Geochemistry*, 2010, 25, (3), 456–471.

In this study, the geochemistry and origin of natural gas and formation waters in Devonian age organic-rich shales and reservoir sandstones across the northern Appalachian Basin margin (western New York, eastern Ohio, northwestern Pennsylvania, and eastern Kentucky) were investigated. Additional samples were collected from Mississippian Berea Sandstone, Silurian Medina Sandstone and Ordovician Trenton/Black River Group oil and gas wells for comparison. Dissolved gases in shallow groundwaters in Devonian organic-rich shales along Lake Erie contain detectable CH_4 (0.01–50.55 mol%) with low $\delta^{13}C$–CH_4 values (−74.68 to −57.86‰) and no higher chain hydrocarbons, characteristics typical of microbial gas. Nevertheless, these groundwaters have only moderate alkalinity (1.14–8.72 meq/kg) and relatively low $\delta^{13}C$ values of dissolved inorganic C (DIC) (−24.8 to −0.6‰), suggesting that microbial methanogenesis is limited. The majority of natural gases in Devonian organic-rich shales and sandstones at depth (>168 m) in the northern Appalachian Basin have a low CH_4 to ethane and propane ratios (3–35 mol%; $C_1/C_2 + C_3$) and high $\delta^{13}C$ and δD values of CH_4 (−53.35 to −40.24‰, and −315.0 to −174.6‰, respectively), which increase in depth, reservoir age and thermal maturity; the molecular and isotopic signature of these gases show that CH_4 was generated via thermogenic processes. Despite this, the geochemistry of co-produced brines shows evidence for microbial activity. High $\delta^{13}C$ values of DIC (> +10‰), slightly elevated alkalinity (up to 12.01 meq/kg) and low SO_4 values (<1 mmole/L) in select Devonian organic-rich shale and sandstone formation water samples suggest the presence of methanogenesis, while low $\delta^{13}C$–DIC values (< −22‰) and relatively high SO_4 concentrations (up to 12.31 mmole/L) in many brine samples point to SO_4 reduction, which likely limits microbial CH_4 generation in the Appalachian Basin. Together the formation water and gas results suggest that the vast majority of CH_4 in the Devonian organic-rich shales and sandstones across the northern Appalachian Basin margin is thermogenic in origin. Small accumulations of microbial CH_4 are present at shallow depths along Lake Erie and in western New York state.

10/01544 Effects of temperature and composition on the laminar burning velocity of $CH_4 + H_2 + O_2 + N_2$ flames

Hermanns, R. T. E. *et al. Fuel*, 2010, 89, (1), 114–121.

This work summarizes available measurements of laminar burning velocities in $CH_4 + H_2 + O_2 + N_2$ flames at atmospheric pressure performed using a heat flux method. Hydrogen content in the fuel was varied from 0% to 40%, amount of oxygen in the oxidizer was varied from 20.9% down to 16%, and initial temperature of the mixtures was varied from 298 to 418 K. These mixtures could be formed when enrichment by hydrogen is combined with flue gas recirculation. An empirical correlation for the laminar burning velocity covering a complete range of these measurements is derived and compared with experiments and other correlations from the literature.

10/01545 Experimental study of bluff-body stabilized LPG–H_2 jet diffusion flame with preheated reactant

Mishra, D. P. and Kumar, P. *Fuel*, 2010, 89, (1), 212–218.

The effects of hydrogen, H_2 addition and preheated reactants on bluff-body stabilized LPG–H_2 diffusion flame for two cases: case I preheated air and case II preheated air and fuel are reported in the present paper. Results confirm that the H_2 addition leads to a reduction in flame length. Besides this, the flame length is also observed to be reduced with increasing reactant temperature and lip thickness of the bluff-body. The soot free length fraction (SFLF) for both cases is observed to be increased with H_2 addition to fuel stream, which might have caused due to decrease in the C/H ratio in the flame. Interestingly, the SFLF is observed to be reduced with increasing lip thickness and reactants temperature, which can be attributed to the attenuation in induction period of soot formation and enhanced soot volume fraction, respectively. The NO_x emission level is found to be decreased in a coaxial burner with hydrogen addition for both case I and II. In contrast, the NO_x emission level is observed to be enhanced in a bluff-body stabilized flame. The former can be ascribed to the reduction in residence time of gas mixture, whereas the latter can be explained on the basis of enhanced flame temperature. Besides this, the emission index of NO_x ($EINO_x$) is also found to be enhanced with increase in lip thickness and reactant temperature which may be caused due to both enhanced residence time and thermal effect, respectively.

10/01546 Gases in Taiwan mud volcanoes: chemical composition, methane carbon isotopes, and gas fluxes

Chao, H.-C. *et al. Applied Geochemistry*, 2010, 25, (3), 428–436.

Mud volcanoes are important pathways for CH_4 emission from deep buried sediments; however, the importance of gas fluxes have hitherto been neglected in atmospheric source budget considerations. In this study, gas fluxes have been monitored to examine the stability of their chemical compositions and fluxes spatially, and stable C isotopic ratios of CH_4 were determined, for several mud volcanoes on land in Taiwan. The major gas components are CH_4 (>90%), 'air' (i.e. $N_2 + O_2 + Ar$, 1–5%) and CO_2 (1–5%) and these associated gas fluxes varied slightly at different mud volcanoes in southwestern Taiwan. The Hsiao-kun-shui (HKS) mud volcano emits the highest CH_4 concentration ($CH_4 > 97\%$). On the other hand, the Chung-lun mud volcano (CL) shows CO_2 up to 85%, and much lower CH_4 content (<37%). High CH_4 content (>90%) with low CO_2 (<0.2%) are detected in the mud volcano gases collected in eastern Taiwan. It is suggestive that these gases are mostly of thermogenic origin based on C_1 (methane)/C_2 (ethane) + C_3 (propane) and $\delta^{13}C_{CH4}$ results, with the exception of mud volcanoes situated along the Gu-ting-keng (GTK) anticline axis showing unique biogenic characteristics. Only small CH_4 concentration variations, <2%, were detected in four on-site short term field-monitoring experiments, at Yue-shi-jie A, B, Kun-shui-ping and Lo-shan A. Preliminary estimation of CH_4 emission fluxes for mud volcanoes on land in Taiwan fall in a range between 980 and 2010 tons annually. If soil diffusion were taken into account, the total amount of mud volcano CH_4 could contribute up to 10% of total natural CH_4 emissions in Taiwan.

Transport, storage

10/01547 Carbon capture and storage: fundamental thermodynamics and current technology

Page, S. C. *et al. Energy Policy*, 2009, 37, (9), 3314–3324.

Carbon capture and storage (CCS) is considered a leading technology for reducing CO_2 emissions from fossil-fuelled electricity generation plants and could permit the continued use of coal and gas whilst meeting greenhouse gas targets. However considerable energy is required for the capture, compression, transport and storage steps involved. In this paper, energy penalty information in the literature is reviewed, and thermodynamically ideal and 'real world' energy penalty values are calculated. For a sub-critical pulverized coal (PC) plant, the energy penalty values for 100% capture are 48.6% and 43.5% for liquefied CO_2, and for CO_2 compressed to 11 MPa, respectively. When assumptions for supercritical plants were incorporated, results were in broad agreement with published values arising from process modelling. However, the authors show that energy use in existing capture operations is considerably greater than indicated by most projections. Full CCS demonstration plants are now required to verify modelled energy penalty values. However, it appears unlikely that CCS will deliver significant CO_2 reductions in a timely fashion. In addition, many uncertainties remain over the permanence of CO_2 storage, either in geological formations, or beneath the ocean. It is concluded that further investment in CCS should be seriously questioned by policy makers.

10/01548 Hydrology, hydrochemistry and geothermal potential of El Chichón volcano-hydrothermal system, Mexico

Taran, Y. A. and Peiffer, L. *Geothermics*, 2009, 38, (4), 370–378.

Fluid and heat discharge rates of thermal springs of El Chichón volcano were measured using the chloride inventory method. Four of the five known groups of hot springs discharge near-neutral Na–Ca–Cl–SO_4 waters with a similar composition ($Cl \sim 1500–2000\ mg\ kg^{-1}$ and $Cl/SO_4 \sim 3$) and temperatures in the 50–74 °C range. The other group discharges acidic (pH 2.2–2.7) Na–Cl water of high salinity (<15 g/L). All five groups are located on the volcano slopes, 2–3 km in a straight line from the bottom of the volcano crater. They are in the upper parts of canyons where thermal waters mix with surface meteoric waters and form thermal streams. All these streams flow into the Río Magdalena, which is the only drainage of all thermal waters coming from the volcano. The total Cl and SO_4 discharges measured in the Río Magdalena downstream from its junction with all the thermal streams are very close to the sum of the transported Cl and SO_4 by each of these streams, indicating that the infiltration through the river bed is low. The net discharge rate of hydrothermal Cl measured for all thermal springs is about $468\ g\ s^{-1}$, which corresponds to $234\ kg\ s^{-1}$ of hot water with $Cl = 2000\ mg\ kg^{-1}$. Together with earlier calculations of the hydrothermal steam output from the volcano crater, the total natural heat output from El Chichón is estimated to be about 160 MWt. Such a high and concentrated discharge of thermal waters from a hydrothermal system is not common and may indicate the high geothermal potential of the system. For the deep water temperatures in the 200–250 °C range (based on geothermometry), and a mass flow rate of $234\ kg\ s^{-1}$, the total heat being discharged by the upflowing hot waters may be 175–210 MWt.

10/01549 Impacts of equations of state (EOS) and impurities on the volume calculation of CO_2 mixtures in the applications of CO_2 capture and storage (CCS) processes

Li, H. and Yan, J. *Applied Energy*, 2009, 86, (12), 2760–2770.

Volume property is the necessary thermodynamic property in the design and operation of the CO_2 capture and storage system (CCS). Because of their simple structures, cubic equations of state (EOS) are preferable to be applied in predicting volumes for engineering applications. This paper evaluates the reliabilities of seven cubic EOS, including PR, PT, RK, SRK, MPR, MSRK and ISRK for predicting volumes of binary CO_2 mixtures containing CH_4, H_2S, SO_2, Ar and N_2, based on the comparisons with the collected experimental data. Results show that for calculations on the volume properties of binary CO_2 mixtures, PR and PT are generally superior to others for all of the studied mixtures. In addition, it was found that the binary interaction parameter has clear effects on the calculating accuracy of an EOS in the volume calculations of CO_2 mixtures. In order to improve the accuracy, k_{ij} was calibrated for all of the EOS regarding the gas and liquid phases of all the studied binary CO_2 mixtures, respectively.

10/01550 Optimizing geologic CO_2 sequestration by injection in deep saline formations below oil reservoirs

Han, W. S. and McPherson, B. J. *Energy Conversion and Management*, 2009, 50, (10), 2570–2582.

The purpose of this research is to present a best-case paradigm for geologic CO_2 storage: CO_2 injection and sequestration in saline formations below oil reservoirs. This includes the saline-only section below the oil–water contact (OWC) in oil reservoirs, a storage target neglected in many current storage capacity assessments. This also includes saline aquifers (high porosity and permeability formations) immediately below oil-bearing formations. While this is a very specific injection target, the authors contend that most, if not all, oil-bearing basins in the US contain a great volume of such strata, and represent a rather large CO_2 storage capacity option. The purpose of this research is to evaluate this hypothesis. CO_2 behaviour in oil reservoirs and brine formations was quantitatively compared by examining the thermo-physical properties of CO_2, CO_2–brine, and CO_2–oil in various pressure, temperature, and salinity conditions. In addition, the distribution of gravity number (N), which characterizes a tendency towards buoyancy-driven CO_2 migration, and mobility ratio (M), which characterizes the impeded CO_2 migration, was compared in oil reservoirs and brine formations. The research suggests competing advantages and disadvantages of CO_2 injection in oil reservoirs vs brine formations: (1) CO_2 solubility in oil is significantly greater than in brine (over 30 times); (2) the tendency of buoyancy-driven CO_2 migration is smaller in oil reservoirs because density contrast between oil and CO_2 is smaller than it between brine and oil (the approximate density contrast between CO_2 and crude oil is $\sim 100\ kg/m^3$ and between CO_2 and brine is $\sim 350\ kg/m^3$); (3) the increased density of oil and brine due to the CO_2 dissolution is not significant (about 7–15 kg/m^3); (4) the viscosity reduction of oil due to CO_2 dissolution is significant (from 5790 to 98 mPa s). These competing properties and processes were compared by performing numerical simulations. Results suggest that deep saline CO_2 injection immediately below oil formations reduces buoyancy-driven CO_2 migration and, at the same time, minimizes the amount of mobile CO_2 compared to conventional deep saline CO_2 injection (i.e. CO_2 injection into brine formations not below oil-bearing strata). Finally, to investigate practical aspects and field applications of this injection paradigm, the authors characterized oil-bearing formations and their thickness (capacity) as a component of the Southwest

Regional Partnership on Carbon Sequestration (SWP) field deployments. The field-testing program includes specific sites in Utah, New Mexico, Wyoming, and western Texas of the USA.

10/01551 Screening and selection of sites for CO_2 sequestration based on pressure buildup

Mathias, S. A. *et al. International Journal of Greenhouse Gas Control*, 2009, 3, (5), 577–585.

This paper presents a simple methodology for estimating pressure build-up due to the injection of supercritical CO_2 into a saline formation, and the limiting pressure at which the formation starts to fracture. Pressure build-up is calculated using the approximate solution of Mathias and colleagues, which accounts for two-phase Forchheimer flow (of supercritical CO_2 and brine) in a compressible porous medium. Compressibility of the rock formation and both fluid phases are also accounted for. Injection pressure is assumed to be limited by the pressure required to fracture the rock formation. Fracture development is assumed to occur when pore pressures exceed the minimum principal stress, which in turn is related to the Poisson's ratio of the rock formation. Detailed guidance is also offered concerning the estimation of viscosity, density and compressibility for the brine and CO_2. Example calculations are presented in the context of data from the Plains CO_2 Reduction (PCOR) Partnership. Such a methodology will be useful for screening analysis of potential CO_2 injection sites to identify which are worthy of further investigation.

Economics, business, marketing, policy

10/01552 Assessment of demand for natural gas from the electricity sector in India

Shukla, P. R. *et al. Energy Policy*, 2009, 37, (9), 3520–3534.

Electricity sector is among the key users of natural gas. The sustained electricity deficit and environment policies have added to an already rising demand for gas. This paper tries to understand gas demand in future from electricity sector. This paper models the future demand for gas in India from the electricity sector under alternative scenarios for the period 2005–2025, using bottom-up ANSWER MARKAL model. The scenarios are differentiated by alternate economic growth projections and policies related to coal reforms, infrastructure choices and local environment. The results across scenarios show that gas competes with coal as a base-load option if price difference is below US$4 per MBtu. At higher price difference gas penetrates only the peak power market. Gas demand is lower in the high economic growth scenario, since electricity sector is more flexible in substitution of primary energy. Gas demand reduces also in cases when coal supply curve shifts rightwards such as under coal reforms and coal-by-wire scenarios. Local environmental (SO_2 emissions) control promotes end of pipe solutions flue gas desulfurization initially, though in the longer term mitigation happens by fuel substitution (coal by gas) and introduction of clean coal technologies integrated gasification combined cycle.

10/01553 Combined effects of initial pressure and turbulence on explosions of hydrogen-enriched methane/air mixtures

Cammarota, F. *et al. Journal of Loss Prevention in the Process Industries*, 2009, 22, (5), 607–613.

Hydrogen-enrichment has been proposed as a useful method to overcome drawbacks (local flame extinction, combustion instabilities, lower power output, etc.) associated to turbulent premixed combustion of natural gas in both stationary and mobile systems. For the safe use of hydrogen-enriched hydrocarbon fuels, explosion data are needed. In this work, a comparative experimental study of the explosion behaviour of stoichiometric hydrogen-enriched methane/air (with 10% of hydrogen molar content in the fuel) and pure methane/air mixtures is presented. Tests were carried out in a 5 l closed cylindrical vessel at different initial pressures (1, 3 and 6 bar), and starting from both quiescent and turbulent conditions. Results allow quantifying the combined effects of hydrogen substitution to methane, pressure and turbulence on maximum pressure, maximum rate of pressure rise, burning velocity and Markstein lengths.

10/01554 Gas and power: Singapore seeks to reduce role of gas

Anon., *Oil and Energy Trends*, 2010, 35, (3), 7–8.

Singapore is seeking ways of reducing its reliance on natural gas for power production. Currently, gas is currently supplied to Singapore by pipelines from Malaysia and Indonesia, but future options for energy supplies include coal-fired generation and nuclear power. However, the city-state has recently awarded contracts for the construction of a liquefied natural gas (LNG)-receiving terminal and plans to use this as an export terminal, so becoming a gas trading centre.

10/01555 Geopolitics of European natural gas demand: supplies from Russia, Caspian and the Middle East

Bilgin, M. *Energy Policy*, 2009, 37, (11), 4482–4492.

This paper addresses issues of natural gas which raise questions about European energy security. It first focuses on the rising gas demand of the EU27 and elaborates alleged risks of dependence on Russia such as Gazprom's disagreement with Ukraine, which became an international gas crisis in January 2006 and also more recently in January 2009. Incentives and barriers of Europe's further cooperation with selected Caspian (Azerbaijan, Kazakhstan and Turkmenistan) and Middle Eastern (Iran, Iraq and Egypt) countries are discussed. Supplies from Caspian are analysed with a particular focus on Russia's role and the vested interests in the region. Supplies from the Middle East are elaborated with regard to Iran's huge and Iraq's emerging potentials in terms of natural gas reserves and foreign direct investments in the energy sector. The geopolitical analysis leads to a conclusion that the best strategy, and what seems more likely, for the EU is to include at least two countries from Azerbaijan, Turkmenistan, Iran and Iraq within its natural gas supply system.

10/01556 Modeling and estimation of the natural gas consumption for residential and commercial sectors in Iran

Forouzanfar, M. *et al. Applied Energy*, 2010, 87, (1), 268–274.

In this paper, a logistic based approach is used to forecast the natural gas consumption for residential as well as commercial sectors in Iran. This approach is relatively simple compared with other forecasting approaches. To make this approach even simpler, two different methods are proposed to estimate the logistic parameters. The first method is based on the concept of the non-linear programming (NLP) and the second one is based on genetic algorithm (GA). The forecast implemented in this paper is based on yearly and seasonal consumptions. In some unusual situations, such as abnormal temperature changes, the forecasting error is as high as 8.76%. Although this error might seem high, one does not need to be deeply concerned about the overall results since these unusual situations could be filtered out to yield more reliable predictions. In general, the overall results obtained using NLP and GA approaches are as well as or even in some cases better than the results obtained using some older approaches such as Cavallini's. These two approaches along with the gas consumption data in Iran for the previous 10 years are used to predict the consumption for the eleventh, twelfth, and thirteenth years. It is shown that the logistic approach with the use of NLP and GA yields very promising results.

10/01557 Natural gas demand in Turkey

Erdogdu, E. *Applied Energy*, 2010, 87, (1), 211–219.

On average, energy demand of Turkey is mounting by 8% annually, one of the highest rates in the world. Among primary energy sources, natural gas is the fastest growing one in Turkey. Gas consumption started at 0.5 bcm (billion cubic metres) in 1987 and reached approximately 35 bcm in 2007. Turkish natural gas usage is projected to further increase remarkably in coming years. The present paper focuses the characteristics of this demand and estimates short and long-run price and income elasticities of sectoral natural gas demand in Turkey. The future growth in this demand is also forecasted using an ARIMA modelling and the results are compared with official projections. The paper reveals that natural gas demand elasticities are quite low, meaning that consumers do not respond possible abusive price increases by decreasing their demand or substituting natural gas with other energy sources. Since consumers are prone to monopoly abuse by incumbent, there is a need for market regulation in Turkish natural gas market. Based on forecasts obtained, it is clear that the current official projections do not over/under-estimate natural gas demand although past official projections highly overestimated it.

10/01558 Ordinal benefits vs economic benefits as a reference guide for policy decision making. The case of hydrogen technologies

Giannantoni, C. *Energy*, 2009, 34, (12), 2230–2239.

The paper presents an investment evaluation method in energetic–economic–environmental field which is particularly indicated for hydrogen technologies because it enables us to account not only for the traditional economic return and the possible negative externalities (damages), but also for: (1) the induced economic benefits at a social level; (2) those positive (and negative) externalities usually considered as being estimable in economic terms as 'proxies'; (3) and, finally, ordinal benefits, that is those benefits which are not reducible to a simple monetary value, nonetheless they can always be object of a possible estimation, still in economic terms, by means of values understood as a 'cipher'. The advantages of a decision making process based on ordinal benefits (vs traditional economic benefits) will be shown with reference to the evaluation of well-calibrated incentives concerning hydrogen fuel cells, both under static and dynamic conditions. Such an evaluation criterion, which is preferentially based on the estimated external benefits to be ‘remunerated’ rather than on possible damages to be internalized, represents a valid reference guide for a policy maker. This is precisely because it is always orientated toward the genesis of the maximum ordinality excess.

10/01559 Prospects of gas supply until 2020 in Europe and its relevance for the power sector in the context of emission trading

Möst, D. and Perlwitz, H. *Energy*, 2009, 34, (10), 1510–1522.

With the liberalization of energy markets and the introduction of an emission trading system, electricity production by gas combined cycle power plants has significantly increased in the European Union in recent years. Reasons for the significant increase include the short construction time for gas power plants and the favourable investment costs. One further advantage is the relatively low CO_2 emissions of gas power plants. Thus, a key option for reducing emissions is seen in the increased use of gas for power production. Model calculations from various models show that an increase of gas power production is expected. In general, however, the interdependencies of the different markets (gas, electricity and CO_2) as well as the country-specific gas supply options, determined by pipelines and liquefied natural gas (LNG), are neglected. As the competitiveness of gas power plants mainly depends on the availability of gas and the gas price, a novel model that integrates electricity, gas, and CO_2-emission markets assuming perfect competition will be presented. The objective of this paper is to analyse the long-term relevance of the gas market for the electricity sector in the European Union in the context of CO_2-emission reduction targets.

10/01560 Russian gas exports have potential to grow through 2020

Fernandez, R. *Energy Policy*, 2009, 37, (10), 4029–4037.

This paper analyses the potential for Russian gas export growth through the next decade and concludes that supply for exports will continue to grow, albeit moderately. The greater or lesser intensity of that growth will depend on the evolution of both production and internal consumption. From the production side, the pace of growth depends on the status of gas reserves and, more importantly, on the investment program pursued by the state-owned gas giant Gazprom. From the demand side, evolution depends on the way Russia’s wide potential for gas savings is managed. Through this analysis, three likely scenarios are found for Russian gas exports. In the most positive, diversification of exports will be possible. In the most negative, Russia will have scant opportunity to develop an export diversification strategy.

10/01561 Scenarios for remote gas production

Tangen, G. and Mølnvik, M. J. *Applied Energy*, 2009, 86, (12), 2681–2689.

The amount of natural gas resources accessible via proven production technology and existing infrastructure is declining. Therefore, smaller and less accessible gas fields are considered for commercial exploitation. The research project ‘Enabling production of remote gas’ builds knowledge and technology aiming at developing competitive remote gas production based on floating LNG and chemical gas conversion. In this project, scenarios are used as basis for directing research related to topics that affect the overall design and operation of such plants. Selected research areas are safety, environment, power supply, operability and control. The paper summarizes the scenario building process as a common effort among research institutes and industry. Further, it documents four scenarios for production of remote gas and outlines how the scenarios are applied to establish research strategies and adequate plans in a multidisciplinary project. To ensure relevance of the scenarios, it is important to adapt the building process to the current problem and the scenarios should be developed with extensive participation of key personnel.

10/01562 System-level energy efficiency is the greatest barrier to development of the hydrogen economy

Page, S. and Krumdieck, S. *Energy Policy*, 2009, 37, (9), 3325–3335.

Current energy research investment policy in New Zealand is based on assumed benefits of transitioning to hydrogen as a transport fuel and as storage for electricity from renewable resources. The hydrogen economy concept, as set out in recent commissioned research investment policy advice documents, includes a range of hydrogen energy supply and consumption chains for transport and residential energy services. The benefits of research and development investments in these advice documents were not fully analysed by cost or improvements in energy efficiency or green house gas emissions reduction. This paper sets out a straightforward method to quantify the system-level efficiency of these energy chains. The method was applied to transportation and stationary heat and power, with hydrogen generated from wind energy, natural gas and coal. The system-level efficiencies for the hydrogen chains were compared to direct use of conventionally generated electricity, and with internal combustion engines operating on gas- or coal-derived fuel. The hydrogen energy chains were shown to provide little or no system-level efficiency improvement over conventional technology. The current research investment policy is aimed at enabling a hydrogen economy without considering the dramatic loss of efficiency that would result from using this energy carrier.

Derived gaseous fuels

10/01563 A new approach to catalytic coal gasification: the recovery and reuse of calcium using biomass derived crude vinegars

Zhang, Y. *et al. Fuel*, 2010, 89, (2), 417–422.

A new concept in catalytic coal gasification has been developed. The use of crude vinegars (CVs) derived from different lignocellulosic biomass resources is described for the recovery and reuse of calcium in coal gasification. Calcium introduced by impregnation with a CV solution produced a higher catalytic activity than calcium loaded by impregnation with an aqueous acetic acid solution. Furthermore, CVs were found to be capable of reclaiming calcium from gasification residue and of improving the catalytic activity of the indigenous crystalline calcite in bituminous coal as *in situ* catalyst.

10/01564 High-pressure gasification reactivity of biomass chars produced at different temperatures

Fermoso, F. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 85, (1–2), 287–293.

The knowledge of biomass char gasification kinetics is of considerable importance in the design of advanced biomass gasifiers, some of which operate at high pressures. In the present work the effects of pyrolysis temperature, total pressure and CO_2 concentration on the gasification of biomass chars have been studied using the thermogravimetric approach. The chars were obtained by pyrolysis in a drop tube furnace reactor at temperatures of 1000 and 1400 °C. The gasification tests were carried out in a pressurized thermogravimetric analyser (PTGA) at different temperatures, pressures and CO_2 concentrations. The reactivity measurements were conducted under the kinetically controlled regime, and three *n*th-order kinetic models as well as the Langmuir–Hinshelwood model were applied to determine the kinetic parameters.

10/01565 Interactions of nickel/zirconia solid oxide fuel cell anodes with coal gas containing arsenic

Coyle, C. A. *et al. Journal of Power Sources*, 2009, 193, (2), 730–738.

The performance of anode-supported and electrolyte-supported solid oxide fuel cells was investigated in synthetic coal gas containing 0–10 ppm arsenic at 700–800 °C. Arsenic was found to interact strongly with nickel, resulting in the formation of nickel–arsenic solid solution, Ni_5As_2 and $Ni_{11}As_8$, depending on temperature, arsenic concentration, and reaction time. For anode-supported cells, loss of electrical connectivity in the anode support was the principal mode of degradation, as nickel was converted to nickel arsenide phases that migrated to the surface to form large grains. Cell failure occurred well before the entire anode was converted to nickel arsenide, and followed a reciprocal square root of arsenic partial pressure dependence that is consistent with a diffusion-based rate-limiting step. Failure occurred more quickly with electrolyte-supported cells, which have a substantially smaller nickel inventory. For these cells, time to failure varied linearly with the reciprocal arsenic concentration. Failure occurred when arsenic reached the anode/electrolyte interface, though agglomeration of nickel reaction products may have also contributed. Test performed with nickel/zirconia coupons showed that arsenic was essentially completely captured in a narrow band near the fuel gas inlet. Arsenic concentrations of 10 ppb or less are estimated to result in acceptable rates of fuel cell degradation.

10/01566 Modeling of catalytic gasification kinetics of coal char and carbon

Zhang, Y. *et al. Fuel*, 2010, 89, (1), 152–157.

Calcium- and potassium-catalysed gasification reactions of coal char and carbon by CO_2 are conducted, and the common theoretical kinetic models for gas–carbon (or char) reaction are reviewed. The obtained experimental reactivities as a function of conversion are compared with those calculated based on the random pore model (RPM), and great deviations are found at low or high conversion levels as predicted by theory. Namely, calcium-catalysed gasification shows enhanced reactivity at low conversion levels of <0.4, whereas potassium-catalysed gasification indicated a peculiarity that the reactivity increases with conversion. CO_2 chemisorption analysis received satisfactory successes in both interpreting catalytic effects and correlating the gasification reactivity with irreversible CO_2 chemical uptakes (CCU_{ir}) of char and carbon at 300 °C. In details, calcium and potassium additions led to significant increases in CCU_{ir} and correspondent high reactivities of the char and carbon. Furthermore, CCU_{ir} of char and carbon decreased with conversion for calcium-catalysed reaction but increased for potassium-catalysed one, corresponded to the tendency of their reactivity. The RPM is extended and applied to these catalytic gasification systems. It is found that the extended RPM predicts the experimental reactivity satisfactorily. The most important finding of this paper is that the empirical constants in the extended RPM correlate well with catalyst loadings on coal.

10/01567 Oxidation of the sulphurised dolomite produced in the desulphurisation of the gasification gases

Álvarez-Rodríguez, R. and Clemente-Jul, C. *Fuel*, 2009, 88, (12), 2507–2519.

Dolomite reacts with H_2S to produce calcium sulfide and has been broadly investigated as a desulfurization agent due to its low-cost and favourable properties. Because CaS reacts with water or water vapour in the environment to regenerate hydrogen sulfide and, therefore, disposal is problematic and the chemical cannot be uses as a landfill material. One of the methods used to make this material inert is oxidation to convert calcium sulfide into calcium sulfate or calcium oxide. In this study, tests were carried out using dolomite from Granada, Spain, that was previously calcined and sulfurized at high temperature with a gas similar to that produced in gasification facilities. To approximate real-scale results, a relatively large amount of substance was used for each sample (100–150 g) and the samples were used in a fixed-bed position. The influence of different conditions, such as grain size, composition of the oxidation gas, gas velocity, bed length and temperature, was them investigated. The final solid products were characterized by X-ray diffraction and chemical analysis and the CO_2, SO_2, H_2S and COS concentrations in the gases produced during oxidation were analysed by gas chromatography. The results showed that the most influential factor was grain size and that the best oxidant was O_2 mixed with nitrogen. The presence of water vapour increases the residual concentration of CaS in the end product, but increased the CaO content. The higher the oxygen concentration and the higher the gas velocity, the lower the residual content of CaS. CO_2 used alone oxidizes CaS to produce SO_2 and COS, but at very low rates. It also produces some CS_2. Water vapour used alone can also oxidize the CaS to produce H_2S and SO_2 but also at very low velocity. At higher oxidation temperature, between 700°C and 850 °C, lesser residual CaS is obtained in the oxidized product.

10/01568 Steam activation of pyrolytic tyre char at different temperatures

López, G. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 85, (1–2), 539–543.

Activation of tyre char has been carried out using steam as activation agent, and the effect of temperature and activation time has been studied. The char samples used in the activation have been obtained by continuous flash pyrolysis carried out in a conical spouted bed reactor at 500 °C. The activation has been carried out at 850 and 900 °C in a fixed bed reactor. During the process, a mesoporous structure is developed, with a predominant pore diameter of around 500 Å and BET surface areas above 500 m^2/g for both the temperatures studied. Moreover, sulfur content significantly decreases during activation and activated carbons with low sulfur content are obtained. This reduction in content may be the key for the industrial application of tyre-derived-carbons, either as active carbons or as carbon blacks for tyre manufacturing.

10/01569 Thermodynamic comparison of the FICFB and Viking gasification concepts

Gassner, M. and Maréchal, F. *Energy*, 2009, 34, (10), 1744–1753.

Two biomass gasification concepts, i.e. indirectly heated, fast internally circulating fluidized bed (FICFB) gasification with steam as gasifying agent and two-stage, directly heated, fixed bed Viking gasification are compared with respect to their performance as gas generators. Based on adjusted equilibrium equations, the gas composition and the energy requirements for gasification are accurately modelled. Overall energy balances are assessed by an energy integration with the heat cascade concept and considering energy recovery in a steam Rankine cycle. A detailed inventory of energy and exergy losses of the different process sections is presented and potential process improvements due to a better utility choice or feed pretreatment like drying or pyrolysis are discussed. While Viking gasification performs better as an isolated gas generator than state-of-the-art FICFB gasification, there is large potential for improvement of the FICFB system. Furthermore, a concluding analysis of the gasification systems in an integrated plant for synthetic natural gas production shows that FICFB gasification is more suitable overall due to a more advantageous energy conversion related to the producer gas composition.

10/01570 Toxic releases: an environmental performance index for coal-fired power plants

Färe, R. *et al. Energy Economics*, 2010, 32, (1), 158–165.

In order to assess the performance of electric power plants that produce both good and bad outputs, this study uses data from the toxic release inventory to construct an environmental performance index (EPI). It was demonstrated in an earlier study that for the one good output and one air pollutant case, the EPI simplifies to the ratio of good to bad output. This study extends the EPI to include an index of multiple bad outputs. After deriving the index as a Malmquist quantity index, the authors assemble data from 1998 to 2005 on releases of selected toxic chemicals and electricity generation for a sample of coal-fired power plants in the USA to demonstrate how the EPI can provide initial perspectives on trends in releases of toxic chemicals by coal-fired power plants.

10/01571 Valuation of investments in natural resources using contingent-claim framework with application to bituminous coal developments in Korea

Won, C. *Energy*, 2009, 34, (9), 1215–1224.

As Brennan and Schwartz pointed out in their pioneering work, the valuation of natural resources projects is particularly difficult due to the high degree of uncertainty in output prices of resources. In general, there are two competing procedures to evaluate risky projects in natural resources developments. One is decision analytic, based on traditional discounted cash flow and stochastic dynamic programming, and the other is contingent claims analysis, based on the no-arbitrage theory of financial markets. This study used the second approach to develop a new model, and the main contributions are providing a tractable and realistic means of incorporating the option value and optimal timing into the investment decision in natural resources and presenting an example that shows option and timing considerations to be important. The authors demonstrated the validity of the model using both numerical analysis and real data.

LNG

10/01572 A critique of offshore liquefied natural gas (LNG) terminal policy

Whitmore, W. D. *et al. Ocean & Coastal Management*, 2009, 52, (1), 10–16.

The US Maritime Transportation Security Act of 2002 amended the Deepwater Port Act of 1974 to permit the construction of offshore liquefied natural gas (LNG) terminals. Terminals with environmentally destructive open-loop regasification systems were quickly approved in the Gulf of Mexico. This study analysed the political methods of President George W. Bush's administration to determine how it developed offshore LNG. Findings showed that the Bush administration worked closely with the energy industry to promote national energy security and limited the role of certain federal and state agencies through a centralized policy process.

10/01573 Gas and power: Yemen faces uncertain gas future

Anon., *Oil and Energy Trends*, 2010, 35, (2), 7–8.

Yemen has been exporting liquefied natural gas (LNG) since October 2009 and plans to develop sales further. However, the unstable political situation within the country poses a threat to these plans and Yemen is facing further scrutiny on this front from the USA.

10/01574 Market prospects: Technip wins FEED contract for proposed floating LNG unit in Brazil

Anon., *Pump Industry Analyst*, 2010, 2010, (1), 3.

Petrobras has awarded Technip, working with JGC Corp and Modec Inc., a lump sum contract for the front-end engineering design (FEED) of a proposed floating liquefied natural gas unit (FLNG). The FLNG project is being undertaken by the joint venture formed by Petrobras, BG, Repsol and Galp Energia for the pre-salt reservoirs of the Santos basin offshore Brazil. This project would be the first FLNG unit in Brazil and will be designed for a capacity of approximately 2.7 million tons per annum of LNG. A final investment decision on the project will be made by Petrobras once the FEED study and the analysis of other options are completed. Scheduled to be completed by the end of 2010, the FEED study will be executed in Technip's operating centres in Paris, France and Rio de Janeiro, Brazil.

10/01575 Preliminary risk analysis for LNG tankers approaching a maritime terminal

Bubbico, R. *et al. Journal of Loss Prevention in the Process Industries*, 2009, 22, (5), 634–638.

LNG ships may represent a remarkable risk source, especially when approaching a land terminal, not only due to the possible occurrence of maritime accident, but also since they may represent a suitable target for terrorist attacks. A preliminary risk analysis for LNG ships approaching the Panigaglia terminal is carried out: based on literature data and on the characteristics of the location, a spill originated from a sea accident can be excluded; on the contrary, intentional damages may cause the release of a large amount of LNG, giving rise to a pool fire. Consequence analysis shows that dangerous thermal effects are expected within a radius of 700–1500 m; in the location under exam, the impact on resident population will be negligible, for the most probable attack site, and marginal for an occasionally used anchorage, which should be no longer allowed.

Hydrogen generation and storage

10/01576 Batch slurry photocatalytic reactors for the generation of hydrogen from sulfide and sulfite waste streams under solar irradiation

Priya, R. and Kanmani, K. *Solar Energy*, 2009, 83, (10), 1802–1805.

In this study, two solar slurry photocatalytic reactors, i.e. batch reactor (BR) and batch recycle reactor with continuous supply of inert gas (BRRwCG) were developed for comparing their performance. The performance of the photocatalytic reactors were evaluated based on the generation of hydrogen (H_2) from water containing sodium sulfide (Na_2S) and sodium sulfite (Na_2SO_3) ions. The photoreactor of capacity 300 mL was developed with UV–vis transparent walls. The catalytic powders (($CdS/ZnS)/Ag_2S + (RuO_2/TiO_2$)) were kept suspended by means of magnetic stirrer in the BR and gas bubbling and recycling of the suspension in the BRRwCG. The rate constant was found to be 120.86 (einstein^{-1}) for the BRRwCG whereas, for the BR it was found to be only 10.92 (einstein^{-1}). The higher rate constant was due to the fast desorption of products and suppression of e^-/h^+ recombination.

10/01577 Bio-hydrogen production from acetic acid steam-exploded corn straws by simultaneous saccharification and fermentation with *Ethanoligenens harbinense* B49

Xu, J.-F. *et al. International Journal of Energy Research*, 2010, 34, (5), 381–386.

This study shows that it is feasible to produce hydrogen from acetic acid steam-exploded corn straw (ASCS) by simultaneous saccharification and fermentation (SSF) with *Ethanoligenes harbinense* B49. The results indicate that acetic acid can be used in the pretreatment of the corn straw and it could also affect the hydrogen yield. The hydrogen yield of ASCS was 1.3 times higher than the steam-exploded corn straw. The lag-phase time decreased with the increase in the acetic acid concentration. Both factors were effective to the hydrogen yield. Compared with acetic acid concentration, enzyme loading was more effective in SSF. But excessive enzyme loading could inhibit the hydrogen yield of strain B49 from ASCS.

10/01578 $CuCr_2O_4/TiO_2$ heterojunction for photocatalytic H_2 evolution under simulated sunlight irradiation

Yan, J. *et al. Solar Energy*, 2009, 83, (9), 1534–1539.

$CuCr_2O_4/TiO_2$ heterojunction has been successfully synthesized via a facile citric acid (CA)-assisted sol–gel method. Techniques of X-ray diffraction (XRD), transmission electron microscopy (TEM), and UV–vis diffuse reflectance spectrum (UV–vis DRS) have been employed to characterize the as-synthesized nanocomposites. Furthermore, photocatalytic activities of the as-obtained nanocomposites have been evaluated based on the H_2 evolution from oxalic acid solution under simulated sunlight irradiation. Factors such as $CuCr_2O_4$ to TiO_2 molar ratio in the composites, calcination temperature, photocatalyst mass concentration, and initial oxalic acid concentration affecting the photocatalytic hydrogen producing have been studied in detail. The results showed that the nanocomposite of $CuCr_2O_4/TiO_2$ is more efficient than their single part of $CuCr_2O_4$ or TiO_2 in producing hydrogen. The optimized composition of the nanocomposites has been found to be $CuCr_2O_4 \cdot 0.7TiO_2$. And the optimized calcination temperature and photocatalyst mass concentration are 500 °C and 0.8 gl^{-1}, respectively. The influence of initial oxalic acid concentration is consistent with the Langmuir model.

10/01579 Development of an evaluation method for the HTTR-IS nuclear hydrogen production system

Sato, H. *et al. Annals of Nuclear Energy*, 2009, 36, (7), 956–965.

A thermochemical water splitting hydrogen production system based on the iodine sulfur (IS) process is presently under development in Japan Atomic Energy Authority (JAEA). The hydrogen production system is to be connected to the HTTR operating test reactor in JAEA. An important development goal for the high-temperature engineering test reactor (HTTR)-IS system is design and construction of the IS process to the standards of a conventional chemical industrial plant in order to simplify the cost and operation of the overall nuclear hydrogen production. The present study considers a method to evaluate the effects of anticipated abnormal load changes in the IS process on the reactor operation. The numerical models are developed with capability to compute abnormal transient behaviour of process heat exchangers in the IS process. Furthermore, interface schemes between the RELAP5 code and the models are developed to quantify the impact of IS process load change events on the reactor operation. A preliminary analysis in case of inadvertent opening of pressure control valve in the H_2SO_4 decomposition procedure of the HTTR-IS system has been conducted. The results of the analysis show that the abnormal load increase of the IS process due to the decrease in boiling and dew point in the H_2SO_4 decomposer and to the chemical equilibrium shift of the H_2SO_4 decomposition is successfully simulated by the chemical reaction and H_2SO_4–H_2O aqueous system models developed. Furthermore, the mitigation effect of a steam generator installed alongside the IS process against abnormal load transient in the reactor is clarified by the developed algorithm interfacing the chemistry model calculation with the system analysis that considers the heat conduction in heat transfer tubes. It is shown that the thermochemical models and model interface schemes developed in the present study make possible the system analysis of the HTTR-IS nuclear hydrogen production during the IS process abnormal events.

10/01580 Development of copper-doped TiO_2 photocatalyst for hydrogen production under visible light

Yoong, L. S. *et al. Energy*, 2009, 34, (10), 1652–1661.

The advantage of copper doping onto TiO_2 semiconductor photocatalysts for enhanced hydrogen generation under irradiation at the visible range of the electromagnetic spectrum has been investigated. Two methods of preparation for the copper-doped catalyst were selected – complex precipitation and wet impregnation methods – using copper nitrate trihydrate as the starting material. The dopant loading varied from 2 to 15%. Characterization of the photocatalysts was done by thermogravimetric analysis (TGA), temperature programmed reduction (TPR), diffuse reflectance UV-Vis (DR-UV-Vis), scanning electron microscopy (SEM), Fourier transform infrared (FTIR) spectroscopy and X-ray diffraction (XRD). Photocatalytic activity towards hydrogen generation from water was investigated using a multiport photocatalytic reactor under visible light illumination with methanol added as a hole scavenger. Three calcination temperatures were selected – 300, 400 and 500 °C. It was found that 10 wt.% Cu/TiO_2 calcined at 300 °C for 30 min yielded the maximum quantity of hydrogen. The reduction of band gap as a result of doping was estimated and the influence of the process parameters on catalytic activity is explained.

10/01581 Efficient hydrogen gas production from cassava and food waste by a two-step process of dark fermentation and photo-fermentation

Zong, W. *et al. Biomass and Bioenergy*, 2009, 33, (10), 1458–1463.

A two-step process of sequential anaerobic (dark) and photo-heterotrophic fermentation was employed to produce hydrogen from cassava and food waste. In dark fermentation, the average yield of hydrogen was approximately 199 ml H_2 g^{-1} cassava and 220 ml H_2 g^{-1} food waste. In subsequent photo-fermentation, the average yield of hydrogen from the effluent of dark fermentation was approximately 611 ml H_2 g^{-1} cassava and 451 ml H_2 g^{-1} food waste. The total hydrogen yield in the two-step process was estimated as 810 ml H_2 g^{-1} cassava and 671 ml H_2 g^{-1} food waste. Meanwhile, the COD decreased greatly with a removal efficiency of 84.3% in cassava batch and 80.2% in food waste batch. These results demonstrate that cassava and food waste could be ideal substrates for bio-hydrogen production. And a two-step process combining dark fermentation and photo-fermentation was highly improving both bio-hydrogen production and removal of substrates and fatty acids.

10/01582 Hydrogen production and storage – investigation of Hf-based intermetallics

Stojić, D. L. *et al. Journal of Power Sources*, 2009, 193, (1), 165–169.

Hafnium-based intermetallics Hf_2Fe, Hf_2Co and Hf_2Ni are investigated as hydrogen absorbers at atmospheric pressure and their electrocatalytic activities are compared. The absorption process is carried out in typical volumetric apparatus. Their crystal structures and morphological characteristics are investigated by X-ray difractometry (XRD) and scanning electron microscopy (SEM). According to the absorption abilities, the investigated intermetallics can be ordered as follows: $Hf_2Fe > Hf_2Co > Hf_2Ni$. *Ab initio* calculations, within the framework of the density functional theory (DFT), as implemented in the full-potential (linearized) augmented plane-wave (FP/LAPW) method, confirms the experimental investigations. The calculations are important as a way of predicting the best cathode and storage materials.

10/01583 Hydrogen production from glycerol: an update

Adhikari, S. *et al. Energy Conversion and Management*, 2009, 50, (10), 2600–2604.

The production of alternative fuels such as biodiesel and ethanol has increased over the last few years. Such fuels are vital for the reduction of energy dependence on foreign countries and to protect the environmental damage associated with the use of fossil fuels. Due to the increased production of biodiesel, a glut of crude glycerol has resulted in the market and the price has plummeted over the past few years. Therefore, it is imperative to find alternative uses for glycerol. A variety of chemicals and fuels including hydrogen can be produced from glycerol. Hydrogen is produced by using several processes, such as steam reforming, autothermal reforming, aqueous-phase reforming and supercritical water reforming. This paper reviews different generation methods, catalysts and operating conditions used to produce hydrogen using glycerol as a substrate. Most of the studies were focused on hydrogen production via steam reforming process and still less work has been done on producing hydrogen from crude glycerol.

10/01584 Hydrogen production from solar thermal dissociation of natural gas: development of a 10 kW solar chemical reactor prototype

Rodat, S. *et al. Solar Energy*, 2009, 83, (9), 1599–1610.

This study addresses the solar thermal decomposition of natural gas for the co-production of hydrogen, as well as carbon black as a high-value nano-material, with the bonus of zero CO_2 emissions. The work focused on the development of a medium-scale solar reactor (10 kW) based on the concept of indirect heating. The solar reactor is composed of a cubic cavity receiver (20 cm side), which absorbs concentrated solar irradiation through a quartz window via a 9 cm-diameter aperture. The reacting gas flows inside four graphite tubular reaction zones that are settled vertically inside the cavity. Experimental results were as follows: methane conversion and hydrogen yield of up to 98% and 90%, respectively, were achieved at 1770 K, and acetylene was the most important by-product, with a mole fraction up to about 5%. The effect of the methane mole fraction in the feed gas, the residence time and the temperature on the reaction extent was analysed. In addition to the experimental section, thermal simulations were carried out. They showed a homogeneous temperature distribution inside the cavity receiver of the reactor and permit to draw up a thermal balance.

10/01585 Hydrogen transportation systems: elements of risk analysis

Gerboni, R. and Salvador, E. *Energy*, 2009, 34, (12), 2223–2229.

This paper describes the methodology and the results obtained in the framework of the NEEDS (New Energy Externalities Developments for Sustainability) European project, while evaluating externalities due to accidental situations. In particular it focuses on the results obtained from a risk assessment of hydrogen transportation technologies. The quantification of risk as an additional source of externality to the cost of transporting hydrogen was obtained with the support of a commercial numerical simulation software that was specifically designed to deal with hazards in process industry environment. A number of scenarios and site dependencies have been taken into account in order to assess the risk associated with different transportation means, under several accidental conditions (e.g. kind of rupture and weather conditions). Results were compared with social acceptability limits of risk set by some countries.

10/01586 Kinetic study on the thermal degradation of a biomass and its compost: composting effect on hydrogen production

Barneto, A. G. *et al. Fuel*, 2010, 89, (2), 462–473.

Composting of *Leucaena* biomass increases hydrogen production from 15.2 to 22.6 vol% in raw gas obtained in air gasification. This fact, which is accompanied with a diminution in carbon monoxide concentration, is a consequence of physicochemical changes associated with composting, mainly in thermophilic stage. After 35 days of maturation, composted biomass do not significantly improves its properties as raw material in biomass gasification. Although composting modifies the chemical composition of the initial biomass (diminishing the holocellulose fraction and increasing lignin and humic fractions), kinetic parameters of the thermal degradation of theses fractions does not significantly change in both materials. Compost can be accepted as a new biomass type with a different component proportions (lignin enriched biomass). In both materials, biomass (*Leucaena*) and compost, mass loss curves during pyrolysis (one step) can be fitted assuming three independent fractions (hemicellulose, cellulose and lignin) which undergo thermal degradation. Cellulosic fraction degrades (first-order reaction) in a narrow temperature range, reaching a maximum mass loss rate near 340 °C. Thermal degradation of the hemicellulosic fraction begins at low temperatures (150 °C) and finishes close to 350 °C. The lignin fraction volatilizes (third-order reaction) in a broad peak, beginning close to 150 °C and finishing close to 700 °C. Mass losses during biomass (*Leucaena*) combustion can be fitted supposing two fractions (holocellulose and lignin), which undergo two consecutives processes: volatization and char combustion. In order to fit the mass losses during compost combustion, it is necessary to introduce a new component: humic fraction, which undergoes the same processes as biomass. In this case, the peak associated to char combustion is a sum of three sub-peaks partially overlapped. In a similar way to pyrolysis, combustion kinetic parameters are close in both biomass and compost. Simulating thermogravimetric analysis it is possible to monitor chemical changes that occur in biomass during composting. Comparing results with obtained from chemical analysis, it was proved that optimization of a suitable combustion model allows the calculation of an approximate composition of samples. In this sense, in order to obtain more reliable data, it is necessary to improve fitting using more complex kinetic equations.

10/01587 Superactivated carbide-derived carbons with high hydrogen storage capacity

Sevilla, M. *et al. Energy & Environmental Science*, 2010, 3, (2), 223–227.

Activation of carbide-derived carbon (CDC) with KOH generates superactivated carbons with high surface area (up to $2800\,m^2\,g^{-1}$). The KOH activation, at a CDC/KOH weight ratio of 1:4, was performed at between 600 and 900 °C. Despite a 50% increase in porosity, the activated carbons retain a microporous nature with typically 90% of their surface area and 80% of their pore volume arising from micropores. The small micropores (8–12 Å) of the CDC are retained in the activated carbons, along with the generation of a greater proportion of new 20 Å pores. The size of the larger pores increases slightly at a higher activation temperature. The activated carbons exhibit an enhancement of up to 63% in hydrogen uptake from 3.8 wt% for the CDC to 6.2 wt% at –196 °C and 20 bar. At 1 bar the superactivated CDC carbons store 2.7 wt% hydrogen, which is among the highest values ever reported for activated carbon. An increase in surface oxygen concentration also contributes to the enhanced hydrogen uptake. For example, activation at 600 °C does not alter the textural properties, but enhances hydrogen uptake by *ca.* 30% compared to the CDC due to an apparent higher surface oxygen concentration.

10/01588 The problem of solid state hydrogen storage

Principi, G. *et al. Energy*, 2009, 34, (12), 2087–2091.

The paper contains a short review of the materials under investigation suitable for solid state hydrogen storage, with particular reference to the experimental activity carried out at the laboratory of the Hydrogen Group of Padova University. The research on new materials for solid state hydrogen storage indicates that up to now none of the studied systems has all the required characteristics for practical applications on a large scale. Nevertheless, niche applications are already possible. Moreover, many innovative systems are promising enough to justify active research in the next years, in order to offer to the market efficient, safe and possibly cheap hydrogen reservoirs.

04 BY-PRODUCTS RELATED TO FUELS

10/01589 Aluminium extraction and leaching characteristics of Talcher Thermal Power Station fly ash with sulphuric acid

Nayak, N. and Panda, C. R. *Fuel*, 2010, 89, (1), 53–58.

Although fly ash disposal is of environmental concern, the quality of residues can be improved with respect to high-value applications. Fly ash is considered as a potential source of aluminium and other strategic metals. Leaching and metal extraction behaviour of fly ash collected from Talcher thermal power station have been thoroughly studied using sulfuric acid as extractant. The chemical and mineralogical composition of post-leached samples have been determined. Aluminium extraction by direct leaching at low acid concentration and ambient temperature is not suitable for high recovery. The extraction efficiency of aluminium increases significantly at a higher solid-to-liquid ratio. It is evident that the leachability of metals from fly ash depends on the nature of leaching medium, solid-to-liquid ratio, temperature and leaching time.

10/01590 Characterization of manganese oxide precipitates from Appalachian coal mine drainage treatment systems

Tan, H. *et al. Applied Geochemistry*, 2010, 25, (3), 389–399.

The removal of Mn(II) from coal mine drainage (CMD) by chemical addition/active treatment can significantly increase treatment costs. Passive treatment for Mn removal involves promotion of biological oxidative precipitation of manganese oxides (MnO_x). Manganese(II) removal was studied in three passive treatment systems in western Pennsylvania that differed based on their influent Mn(II) concentrations (20–150 mg/L), system construction (± inoculation with patented Mn(II)-oxidizing bacteria), and bed materials (limestone vs. sandstone). Manganese(II) removal occurred at pH values as low as 5.0 and temperatures as low as 2 °C, but was enhanced at circumneutral pH and warmer temperatures. Trace metals such as Zn, Ni and Co were removed effectively, in most cases preferentially, into the MnO_x precipitates. Based on synchrotron radiation X-ray diffraction and Mn K-edge extended X-ray absorption fine structure spectroscopy, the predominant Mn oxides at all sites were poorly crystalline hexagonal birnessite, triclinic birnessite and todorokite. The surface morphology of the MnO_x precipitates from all sites was coarse and 'sponge-like' composed of nm-sized lathes and thin sheets. Based on scanning electron microscopy (SEM), MnO_x precipitates were found in close proximity to both prokaryotic and eukaryotic organisms. The greatest removal efficiency of Mn(II) occurred at the one site with a higher pH in the bed and a higher influent total organic C (TOC) concentration (provided by an upstream wetland). Biological oxidation of Mn(II) driven by heterotrophic activity was most likely the predominant Mn removal mechanism in these systems. Influent water chemistry and Mn(II) oxidation kinetics affected the relative distribution of MnO_x mineral assemblages in CMD treatment systems.

10/01591 Germanium recovery from gasification fly ash: evaluation of end-products obtained by precipitation methods

Arroyo, F. *et al. Journal of Hazardous Materials*, 2009, 167, (1–3), 582–588.

In this study the purity of the germanium end-products obtained by two different precipitation methods carried out on germanium-bearing solutions was evaluated as a last step of a hydrometallurgy process for the recovery of this valuable element from the Puertollano integrated gasification combined cycle (IGCC) fly ash. Since H_2S is produced as a by-product in the gas cleaning system of the Puertollano IGCC plant, precipitation of germanium as GeS_2 was tested by sulfiding the Ge-bearing solutions. The technological and hazardous issues that surround H_2S handling conducted to investigate a novel precipitation procedure: precipitation as an organic complex by adding 1,2-dihydroxy benzene pyrocatechol (CAT) and cetyltrimethylammonium bromide (CTAB) to the Ge-bearing solutions. Relatively high purity Ge end-products (90 and 93% hexagonal-GeO_2 purity, respectively) were obtained by precipitating Ge from enriched solutions, as GeS_2 sulfiding the solutions with H_2S, or as organic complex with CAT/CTAB mixtures and subsequent roasting of the precipitates. Both methods showed high efficiency (>99%) to precipitate selectively Ge using a single precipitation stage from germanium-bearing solutions.

10/01592 Investigating the effect of metal oxide additives on the properties of $Cu/ZnO/Al_2O_3$ catalysts in methanol synthesis from syngas using factorial experimental design

Meshkini, F. *et al. Fuel*, 2010, 89, (1), 170–175.

The $Cu/ZnO/Al_2O_3$ catalysts, prepared by co-precipitation method, have been modified by adding small amount of Mn, Mg, Zr, Cr, Ba, W and Ce oxides using design of experiments (1/16 full factorial design). The structure and morphology of catalysts were studied by X-ray diffraction (XRD) and BET. Performance of the prepared catalysts for CO/CO_2 hydrogenation to methanol was evaluated by using a stainless steel fixed-bed reactor at 5 MPa and 513 K. The oxide additives were found to influence the catalytic activity, dispersion of Cu, Cu crystallite size, surface composition of catalyst and stability of catalysts during their operations. The results showed that the Mn and Zr promoted catalysts have high performance for methanol synthesis from syngas.

10/01593 New concept for soot removal from a syngas mixture

Raimondi, A. *et al. Journal of Power Sources*, 2009, 193, (1), 338–341.

A new concept for soot removal from inside a syngas environment has been studied. Particulate emissions are retained in a soot trap downstream from a thermal partial oxidation (TPOX) reformer, while the syngas atmosphere itself is utilized as a gasification agent to achieve continuous and passive trap regeneration. This work analyses the performances of the loading and the regenerating phases of a wall flow soot trap in a syngas environment in an ad hoc developed test rig. A balance point between filtered and removed soot was actually reached at trap temperatures in the 800–1000 °C range with soot abatement efficiencies above 95 wt%. The particulate is obtained from a TPOX reactor operating in very rich fuel conditions, using methane as fuel. The final application of the reactor and trap assembly is a micro CHP system, based on an SOFC fed by a TPOX reformer. However, application to larger contexts (e.g. biomass gasification plants) can be envisaged.

10/01594 Pyrolysis and gasification of food waste: syngas characteristics and char gasification kinetics

Ahmed, I. I. and Gupta, A. K. *Applied Energy*, 2010, 87, (1), 101–108.

Characteristics of syngas from the pyrolysis and gasification of food waste has been investigated. Characteristic differences in syngas properties and overall yields from pyrolysis and gasification were determined at two distinct high temperatures of 800 and 900 °C. Pyrolysis and gasification behaviour were evaluated in terms of syngas flow rate, hydrogen flow rate, output power, total syngas yield, total hydrogen yield, total energy yield, and apparent thermal efficiency. Gasification was more beneficial than pyrolysis based on investigated criteria, but longer time was needed to finish the gasification process. Longer time of gasification is attributed to slow reactions between the residual char and gasifying agent. Consequently, the char gasification kinetics was investigated. Inorganic constituents of food char were found to have a catalytic effect. Char reactivity increased with increased degree of conversion. In the conversion range from 0.1 to 0.9 the increase in reactivity was accompanied by an increase in pre-exponential factor, which suggested an increase in gasifying agent adsorption rate to char surface. However, in the conversion range from 0.93 to 0.98 the increase in reactivity was accompanied by a decrease in activation energy. A compensation effect was observed in this range of conversion of 0.93–0.98.

10/01595 Self-sustained reformation of diesel fuel using a SiC block with penetrating walls

Ko, M. K. *et al. International Journal of Energy Research*, 2010, 34, (5), 375–380.

This study developed a new reformation device based on a silicon carbide (SiC) ceramic wall flow monolith. The atomized fuel was spray injected to the electrically heated block. The fuel–air mixture was then reformed by partial oxidation and changed to synthesis gas including CO, CO_2, H_2O, O_2 and H_2. The composition of the reformed gas was measured with varying fuel–air ratios. The degree of reformation or conversion changes with the temperature and a maximum conversion efficiency of 90% is attained at around 850°C.

10/01596 The effect of phosphine in syngas on Ni–YSZ anode-supported solid oxide fuel cells

Xu, C. *et al. Journal of Power Sources*, 2009, 193, (2), 739–746.

Ni–YSZ cermet is commonly used as the anode of a solid oxide fuel cell (SOFC) because it has excellent electrochemical performance, not only in hydrogen fuel, but also in a clean blended synthetic coal syngas mixture (30% H_2, 26% H_2O, 23% CO, and 21% CO_2). However, trace impurities, such as phosphine (PH_3), in coal-derived syngas can cause degradation in cell performance. A commercial solid oxide fuel cell was exposed to a syngas with 10 ppm PH_3 under a constant current load at 800 °C and its performance was evaluated periodically using electrochemical methods. The central part of the anode was exposed directly to the syngas without an intervening current collector. Post-mortem analyses of the SOFC anode were performed using Raman spectroscopy, X-ray diffraction, scanning electron microscopy, energy dispersive spectroscopy and X-ray photoelectron spectroscopy. The results show that the impurity PH_3 caused a significant loss of the Ni–YSZ anode electrochemical performance and an irreversible Ni–YSZ structural modification. Ni_5P_2 was confirmed to be produced on the cell surface as the dominant nickel phosphorus phase.

10/01597 Thermo-economic process model for thermochemical production of synthetic natural gas (SNG) from lignocellulosic biomass

Gassner, M. and Maréchal, F. *Biomass and Bioenergy*, 2009, 33, (11), 1587–1604.

A detailed thermo-economic model considering different technological alternatives for thermochemical production of synthetic natural gas (SNG) from lignocellulosic biomass is presented. First, the candidate technology for processes based on biomass gasification and subsequent methanation is discussed and assembled in a general superstructure. Both energetic and economic models for biomass drying with air or steam, thermal pretreatment by torrefaction or pyrolysis, indirectly and directly heated gasification, methane synthesis and carbon dioxide removal by physical absorption, pressure swing adsorption and polymeric membranes are then developed. Performance computations for the different process steps and some exemplary technology scenarios of integrated plants are carried out, and overall energy and exergy efficiencies in the range of 69–76% and 63–69%, respectively, are assessed. For these scenarios, the production cost of SNG including the investment depreciation is estimated to 76–107 € $MWh^{-1}{}_{SNG}$ for a plant capacity of 20 $MW_{th,biomass}$, whereas 59–97 € $MWh^{-1}{}_{SNG}$ might be reached at scales of 150 $MW_{th,biomass}$ and above. Based on this work, a future thermo-economic optimization will allow for determining the most promising options for the polygeneration of fuel, power and heat.

10/01598 Tracing the interaction of acid mine drainage with coal utilization byproducts in a grouted mine: strontium isotope study of the inactive Omega Coal Mine, West Virginia (USA)

Hamel, B. L. *et al. Applied Geochemistry*, 2010, 25, (2), 212–223.

In order to ameliorate acidic discharge, the inactive Omega coal mine, west Virginia was partially filled by injection of a grout consisting of 98% coal utilization byproducts (CUB), including fluidized bed combustion ash and fly ash, and 2% Portland cement. In this study, discharge chemistry and Sr isotope ratios were determined to identify and quantify the extent of interaction between mine waters and the CUB–cement grout. Eight sampling sites were monitored around the downdip perimeter of the mine. The major and trace element chemistry of the discharges was generally not sufficient to distinguish between discharges that interacted with grout and those that did not. Elements that showed the most separation include K and As, which were elevated in some waters that interacted with CUB–cement grout. In contrast, the Sr isotope ratios clearly distinguished discharges from grouted and non-grouted areas. Discharges that bypassed the grouted portions had $^{87}Sr/^{86}Sr$ ratios ranging from 0.71510 to 0.71594, while two discharges that interacted with grout had ratios in the range of 0.71401–0.71456. The Treatment Inlet, which includes both grouted and ungrouted discharges, yielded intermediate isotopic ratios. Leaching experiments on CUB–cement grout, coal and surrounding rocks are consistent with the isotopic trends observed in the discharges. Based on these results, waters that interacted with grout received 30–40% of their Sr from the CUB–cement grout material. These results suggest that the grout material is chemically eroding at a rate of approximately 0.04% per year. This novel application of the Sr isotope system illustrates its ability to sensitively track and quantify fluid interaction with coal and CUB-based grout.

05 NUCLEAR FUELS

Scientific, technical

10/01599 A model for predicting static instability in two-phase flow systems

Farhadi, K. *Progress in Nuclear Energy*, 2009, 51, (8), 805–812.

An analytical model for predicting the onset of Ledinegg instability in vertical channel under both downflow and upflow conditions has been developed and evaluated. The model divides the flow field into two regions based upon the fluid temperature. The pressure drop is then found by solving an appropriate set of equations for each region. The theoretical results are compared to an existing set of experimental data covering a range of channel diameters and operating conditions. A very good agreement is obtained with the available experimental data from the literature for water systems. A parameter, the ratio between the surface heat flux and the heat flux required to achieve saturation at the channel exit for a given flow rate, is found to be a very accurate indicator of the minimum point velocity in the demand curve.

10/01600 A new physical protection measure for evaluating risks at nuclear facilities

Yoo, H. *Annals of Nuclear Energy*, 2009, 36, (9), 1463–1468.

The physical protection (PP) measures for evaluating risks at nuclear facilities have been developed. The developed measures can be used to not only evaluate the physical protection status of operational nuclear facilities, but also for the next generation of nuclear systems such as the SFR (sodium fast reactor) and the VHTR (very high temperature reactor). These measures can substitute those existing methodologies developed by the Gen-IV PR&PP group and the INPRO. These measures have been adapted to hypothetical nuclear facilities, and scenarios have been created to analyse PP risk quantitatively. The PP measures developed in this study contain probability of interruption (PI), probability of neutralization (PN), consequences (C), fissile material type (MT) and effectiveness of physical protection resources (EPR). In this paper, tools and tables for calculating each PP measure are suggested and illustrated in detail. The PI and PN measures can be calculated quantitatively using these tools. A new computer code for calculating PI has also been developed. The EPR, MT and C measures were obtained from tables developed by collecting and analysing related information. Computational results of the PP measures in five different scenarios, and at three different facilities demonstrate the effectiveness of the methodology developed. The results obtained are represented in a spider diagram (after normalizing the measure calculated). The value of PI and C changed because of the scenario; but the other three measures, EPR, MT and PN (determined by the characteristics of the facility) did not vary. It is expected that by using a larger number of refined scenarios more reliable information will be provided. It is also anticipated that the PP measures developed in this study can be applied to operational nuclear facilities, as well as a future nuclear systems under development.

10/01601 A pebble bed reactor cross section methodology

Hudson, N. H. *et al. Annals of Nuclear Energy*, 2009, 36, (8), 1138–1150.

A method is presented for the evaluation of microscopic cross-sections for the pebble bed reactor (PBR) neutron diffusion computational models during convergence to an equilibrium (asymptotic) fuel cycle. This method considers the isotopics within a core spectral zone and the leakages from such a zone as they arise during reactor operation. The randomness of the spatial distribution of fuel grains within the fuel pebbles and that of the fuel and moderator pebbles within the core, the double heterogeneity of the fuel, and the indeterminate burn-up of the spectral zones all pose a unique challenge for the computation of the local microscopic cross sections. As prior knowledge of the equilibrium composition and leakage is not available, it is necessary to repeatedly re-compute the group constants with updated zone information. A method is presented to account for local spectral zone composition and leakage effects without resorting to frequent spectrum code calls. Fine group data are pre-computed for a range of isotopic states. Microscopic cross-sections and zone nuclide number densities are used to construct fine group macroscopic cross-sections, which, together with fission spectra, flux modulation factors, and zone buckling, are used in the solution of the slowing down balance to generate a new or updated spectrum. The microscopic cross-sections are then re-collapsed with the new spectrum for the local spectral zone. This technique is named the spectral history correction (SHC) method. It is found that this method accurately recalculates local broad group microscopic cross sections. Significant improvement in the core eigenvalue, flux, and power peaking factor is observed when the local cross sections are corrected for the effects of the spectral zone composition and leakage in two-dimensional PBR test problems.

10/01602 Ageing of EUROBITUM bituminised radioactive waste: an ATR-FTIR spectroscopy study

Valcke, E. *et al. Journal of Nuclear Materials*, 2009, 393, (1), 175–185.

The extent of the physico-chemical processes of concern in the study of the acceptability of Eurobitum bituminized radioactive waste for underground disposal (water uptake by hygroscopic $NaNO_3$ – swelling – pressure build-up – $NaNO_3$ leaching) will depend on the degree of ageing of the bituminous matrix. In the work reported here, the ageing behaviour was studied by comparing the characteristics of 25-year-old radioactive Eurobitum with those of 25-year-old non-radioactive Eurobitum samples that were heated or gamma-irradiated in the presence or absence of oxygen. Chemical changes in the bitumen structure were followed in the mid-infrared region with attenuated total reflectance Fourier transform infrared spectroscopy (ATR-FTIR) by measuring the evolution of the band heights at $1700\,cm^{-1}$ (C=O functional groups) and $1600\,cm^{-1}$ (C=C double bonds). Needle penetration depths and ring and ball softening points were determined for some samples. Oxidation of bitumen in the presence of oxygen results in a distinct increase of both the number of C=O and C=C functionalities, with a positive linear relationship existing between the two groups. The production of C=O functional groups seems to promote the generation of C=C double bonds. Heating at 130 °C is much more efficient than gamma irradiation at low to moderate dose rates (20–140 Gy/h) to oxidize the bitumen. As the oxygen concentration decreases, for instance by diffusion limitation deeper inside the bitumen, the number of C=O and CC functionalities formed per unit of time decreases. A similar behaviour was observed for 25-year-old radioactive Eurobitum. In absence of oxygen, gamma irradiation still results in a small increase of the number of C=O functional groups, probably by oxygen still adsorbed on the bitumen, and in a relatively higher amount of C=C double bonds. The surface layer (<5 cm) of 25-year-old radioactive Eurobitum was heavily oxidized. The material had become very hard and brittle, and was full of small fissures. Due to these fissures, radio-oxidation processes took also place deeper inside the waste. The consequences of these observations for the long-term behaviour of Eurobitum in underground disposal conditions are discussed.

10/01603 Analytical solution of point kinetics equations for linear reactivity variation during the start-up of a nuclear reactor

Palma, D. A. P. *et al. Annals of Nuclear Energy*, 2009, 36, (9), 1469–1471.

The analytical solution of point kinetics equations with a group of delayed neutrons is useful in predicting the variation of neutron density during the start-up of a nuclear reactor. In the practical case of an increase of nuclear reactor power resulting from the linear insertion of reactivity, the exact analytical solution cannot be obtained. Approximate solutions have been obtained in previous articles, based on considerations that need to be verifiable in practice. In this article, an alternative analytic solution is presented for point kinetics equations in which the only approximation consists of disregarding the term of the second derivative for neutron density in relation to time. The results proved satisfactory when applied to practical situations in the start-up of a nuclear reactor through the control rods withdraw.

10/01604 Corrosion of the AlFeNi alloy used for the fuel cladding in the Jules Horowitz research reactor

Wintergerst, M. *et al. Journal of Nuclear Materials*, 2009, 393, (3), 369–380.

The AlFeNi aluminium alloy (1 wt% Fe, 1 wt% Ni, 1 wt% Mg) is expected to be used as nuclear fuel cladding for the Jules Horowitz experimental reactor. To guarantee a safe behaviour of the fuel, a good understanding of the fuel clad corrosion mechanisms is required. In this field, the experimental characterization of the selected alloy was performed. Then experimental studies of the aluminium alloy corrosion product obtained in autoclaves have shown an oxide film composed of two layers. This duplex structure results from a mixed growth mechanism: an anionic growth to develop the inner oxide and a cationic diffusion parallel to a dissolution–precipitation process to form the outer zone. Dynamic experiments at 70 °C have demonstrated that a solid diffusion step controls the release kinetic. Then post-irradiation exams performed on irradiated fuel plates were used to investigate the effects of the irradiation on the corrosion behaviour in the reactor core.

10/01605 Development and characterisation of a new ODS ferritic steel for fusion reactor application

Oksiuta, Z. *et al. Journal of Nuclear Materials*, 2009, 393, (1), 114–119.

This paper describes the microstructure, tensile properties and Charpy impact resistance of a reduced activation oxide dispersion strengthened ferritic steel Fe–14Cr–2W–0.3Ti–0.3Y_2O_3 produced by mechanical alloying of a pre-alloyed, gas atomized steel powder with Y_2O_3 particles, compaction by hot extrusion at 1100 °C, hot rolling at 700 °C and heat treatment at 1050 °C for 1 h. At room temperature the material exhibits a high ultimate tensile strength of about 1420 MPa and high yield strength of about 1340 MPa in the transverse direction. In the longitudinal direction the values are about 10% lower, due to the anisotropy of the microstructure (elongated grains in the rolling direction). At 750 °C the material still exhibits relatively high yield strengths of about 325 MPa and 305 MPa in the longitudinal and transverse directions, respectively. The material exhibits reasonable uniform and total elongation values over the temperature range 23–750 °C, in both transverse and longitudinal directions. The material exhibits weak Charpy impact properties in the transverse direction. Charpy impact properties are slightly better in the longitudinal direction, with upper shelf energy of about 4.2 J and a ductile-to-brittle transition temperature of about 8.8 °C.

10/01606 Development of key ITER relevant technologies on the Tore Supra tokamak

Saoutic, B. *Fusion Engineering and Design*, 2009, 84, (2–6), 161–169.

As the largest superconducting tokamak presently in operation, with all plasma-facing components (PFC) actively cooled, Tore Supra is able to routinely address critical issues of high power long duration discharges. Twenty years of operation of Tore Supra have been valorized through ‘lessons learnt’ studies on systems critical for long pulse operation. Real time feedback systems have been developed to safely operate at a high level (>10 MW) of injected power. The versatility of the integrated plasma controller has allowed extending feedbacks to plasma performance optimization. A dedicated long discharges campaign, cumulating 5 h of plasma in 10 operation days without any conditioning procedure meanwhile, has allowed to gain new insights in deuterium retention studies and to reveal a new operational limit characterized by a progressive decreases of the power handling capability. A strong development effort has been undertaken to follow up the PFC ageing during and between experimental campaigns. This includes the development of an articulated inspection arm, of lock-in thermography and confocal microscopy techniques. An important part of the Tore Supra programme, is the development of reliable heating and current drive systems. Progress in the development of lower hybrid couplers, klystrons and test of a load resilient ion cyclotron range of frequency are also reported in the paper.

10/01607 Differential evolution algorithms applied to nuclear reactor core design

Sacco, W. F. *et al. Annals of Nuclear Energy*, 2009, 36, (8), 1093–1099.

The differential evolution algorithm (DE) and a recently introduced variant, differential evolution with random localizations (DERL), are applied for the first time to a nuclear engineering optimization problem. This problem was previously solved with genetic algorithms, particle swarm optimization and Metropolis algorithms, and consists in adjusting several reactor cell parameters, such as dimensions, enrichment and materials, in order to minimize the average peak-factor in a three-enrichment-zone reactor, considering restrictions on the average thermal flux, criticality and sub-moderation. The results obtained by DE and DERL are compared against the published ones and both algorithms perform well, thus demonstrating their potential for other applications.

10/01608 Experimental investigations on mechanical and radiation shielding properties of hybrid lead–steel fiber reinforced concrete

Sharma, A. *et al. Nuclear Engineering and Design*, 2009, 239, (7), 1180–1185.

This paper summarizes the results from the investigations carried out on fibre-reinforced concrete with steel fibres, lead fibres and a combination of the two (hybrid fibres). The intent of this research was to investigate the effect of the two types of fibres on mechanical and radiation shielding properties of concrete. Compressive strength, split tensile strength and flexural toughness were among the mechanical properties investigated and radiation shielding to gamma rays was investigated by comparing the attenuation provided by different types of concrete against each other and against blank readings without attenuation. The results clearly showed that the hybrid fibres showed a significant enhancement in both mechanical and radiation shielding properties.

10/01609 Gel structure of the corrosion layer on cladding pipes of nuclear fuel

Medek, J. and Weishauptová, Z. *Journal of Nuclear Materials*, 2009, 393, (2), 306–310.

The fuel material in a nuclear reactor is protected by cladding pipes made of alloyed zirconium. In contact with water near its critical temperature, a corrosion layer of hydrated zirconium dioxide $ZrOS_2 \cdot nH_2O$, probably with an amorphous gel structure under given conditions, is formed on the cladding. To verify the presence of the gel structure, an analysis was made by water vapour desorption of the original corrosion oxide layers stored in a given autoclave liquid, their dehydrated modifications, and modifications rehydrated in an aqueous medium. This analysis enabled the varying water content to be determined as a characteristic quantity reflecting the nature of its binding. Microhardness values as a measure of plastic deformation of the crystalline and amorphous forms of zirconium dioxide were also determined. Unambiguous agreement of the results obtained by sorption analysis and by microhardness measurement allows us to conclude that the corrosion layer *in situ* has properties corresponding to a reversible xerogel.

10/01610 Geometry and physics of the Geant4 toolkit for high and medium energy applications

Apostolakis, J. *et al. Radiation Physics and Chemistry*, 2009, 78, (10), 859–873.

The current status of the Geant4 toolkit and the recent developments for the geometry, electromagnetic and hadronic physics for medium and high energy are presented. The focus of many recent improvements in the toolkit are key applications including the simulation of large Hadron collider experiments at CERN. These developments and physics model extensions provide new capabilities and improvements for other applications of the toolkit for radiation studies in high energy physics, space and medical research.

10/01611 In-core fuel management optimization of pebble-bed reactors

Boer, B. *et al. Annals of Nuclear Energy*, 2009, 36, (8), 1049–1058.

A reduction of the power peak in the core of high temperature pebble-bed reactors is attractive to decrease the maximum fuel temperature and to increase fuel performance. A calculation procedure was developed, which combines fuel depletion, neutronics and thermal–hydraulics to investigate the impact of a certain (re)loading scheme for the pebble-bed type HTR. The procedure has been applied to a model of the Pebble Bed Modular Reactor (400 MW) design. This paper shows that an important reduction in axial power peaking can be achieved by adopting a multi-pass recycling scheme for the pebbles. By dividing the core into several radial fuel zones in combination with multi-pass recycling the power profile can be flattened in the radial direction. For a core with two fuel zones the impact on the k_{eff} and maximum power density as a function of the zone size has been investigated. A heuristic method has been used to find the optimal pebble loading pattern for several (re)loading schemes. Using this method a reduction of the maximum power density from 10.0 to 8.2 MW/m^3 has been achieved for a core with three radial fuel zones.

The effects of the improved power profiles on the fuel temperature during normal operation and a depressurized loss of coolant (DLOFC) accident have been analysed. It was found that the optimized power profile results in a reduction of the maximum fuel temperature of 80 °C and 300 °C for normal operation and DLOFC conditions, respectively.

10/01612 Integrated decay heat load method to analyze repository capacity impact of a fuel cycle

Li, J. *et al. Annals of Nuclear Energy*, 2009, 36, (9), 1366–1373.

Assessing the needs for repository capacity from nuclear waste disposal is essential for fuel cycle development or repository development planning. As the repository capacity is mainly constrained by thermal design limits on the repository rocks, a detailed mountain-scale heat transfer calculation is needed for repository capacity impact analysis. In this paper, a simplified repository capacity impact analysis method is proposed as an alternative to performing repository scale heat transfer analysis. The method is based on the use of integrated decay heat load (IDHL) limits. The derived integrated decay heat loads were found to appropriately represent the drift wall temperature limit (200 °C) and the midway between adjacent drifts temperature limit (96 °C) under the high temperature operating mode as long as the wastes are uniformly loaded into the repository. Results indicated that the long-term integrated decay heat load ($IDHL_L$) and the short-term integrated decay heat load ($IDHL_S$) can be effectively used to represent the repository capacity impact for spent nuclear fuels and high-level wastes, respectively. Comparisons indicated good agreement between the proposed IDHL method and the repository heat transfer analysis-based approach.

10/01613 Monte Carlo simulations of radioactive waste embedded into polymer

Özdemir, T. and Usanmaz, A. *Radiation Physics and Chemistry*, 2009, 78, (9), 800–805.

Radioactive waste is generated from the nuclear applications and it should properly be managed according to the regulations set by the regulatory authority. Poly(carbonate urethane) and poly(bisphenol a-*co*-epichlorohydrin) are radiation-resistant polymers and they are possible candidate materials that can be used in the radioactive waste management. In this study, maximum allowable waste activity that can be embedded into these polymers and dose rate distribution of the waste drum (containing waste and the polymer matrix) were found via Monte Carlo simulations. The change of mechanical properties of above-mentioned polymers was simulated and their variations within the waste drum were determined for 15, 30 and 300 years after embedding.

10/01614 Processing dynamic scenarios from a reliability analysis of a nuclear power plant digital instrumentation and control system

Zio, E. and Di Maio, F. *Annals of Nuclear Energy*, 2009, 36, (9), 1386–1399.

This paper illustrates a method for processing accident scenarios generated in a dynamic reliability analysis of a nuclear power plant (NPP) equipped with digital instrumentation and control (I&C). The method is based on a fuzzy C-means clustering algorithm for classification, which takes into account not only the system states reached at the end of the scenarios but also the timing and magnitude of the occurred failure events, and the characteristics of the process evolution. An illustrative case study is considered, regarding the fault scenarios of the digital I&C of the lead–bismuth eutectic experimental accelerator driven system (LBE-XADS). A SIMULINK model of the system has been embedded within a Monte Carlo sampling procedure for injecting faults at random times and of random magnitudes. The accident scenarios thereby generated are classified on the basis of three different system end states, which relate to the value reached by the diathermic oil secondary coolant temperature with respect to maximum and minimum safety threshold values set to avoid primary coolant thermal shocks and degradation of the oil physical and chemical properties.

10/01615 Reactor core power measurement using Cherenkov radiation and its application in Tehran Research Reactor

Arkani, M. and Gharib, M. *Annals of Nuclear Energy*, 2009, 36, (7), 896–900.

Cherenkov radiation is a process that could be used as an extra channel for power measurement to enhance redundancy and diversity of a reactor. This is especially easy to establish in a pool type research reactor. A simple photo diode array is used in Tehran Research Reactor to measure and display power in parallel with the existing conventional detectors. Experimental measurements on this channel showed that a good linearity exists above 100 kW range. The system has been in use for more than a year and has shown reliability and precision. Nevertheless, the system is subject to further modifications, in particular for application to lower power ranges.

10/01616 Subchannel analysis of CANDU-SCWR fuel

Li, C. *et al. Progress in Nuclear Energy*, 2009, 51, (8), 799–804.

A cooperative study has been initiated at Xi'an Jiaotong University (XJTU) with Atomic Energy of Canada Limited (AECL) to develop a subchannel code ATHAS for preliminary analyses of flow and enthalpy distributions and cladding temperatures in CANDU fuel at super-critical water conditions. The code is applicable for transient and steady-state calculations. Then the paper uses the ATHAS code to analyse CANDU-SCWR which is operating at 25.0 MPa pressure. The results show that the maximum cladding-surface temperature of CANFLEX bundle is 804.1 °C, which is below the limit of design, and it is appropriate for use in the CANDU super-critical water-cooled reactor (SCWR) based on heat-transfer analysis.

10/01617 Use of poly(methyl methacrylate) in radioactive waste management: II. Monte Carlo simulations

Özdemir, T. and Usanmaz, A. *Progress in Nuclear Energy*, 2009, 51, (8), 845–848.

Radioactive waste is generated from nuclear applications and should properly be managed in a radioactive waste management system. Different methods are available for treatment and conditioning of radioactive waste. Polymers can be used in the radioactive waste management as an embedding matrix. Poly(methyl methacrylate) (PMMA) is a possible candidate material that can be used in low level radioactive waste management. In this study, based on total resistible dose for PMMA, maximum waste activity that can be embedded into a waste drum was found via Monte Carlo simulations. In addition, Monte Carlo simulations for radioactive waste embedded into above mentioned polymer was performed and the dose rate distribution in the polymer matrix was determined for the initial and different periods of 15.1, 30.2 and 302 years after embedding of waste. Changes of mechanical properties in the polymer embedded waste drum was simulated for PMMA embedded waste matrices based on experimental data.

Economics, policy, supplies, forecasts

10/01618 A heuristic model for risk and cost impacts of plant outage maintenance schedule

Mohammad Hadi Hadavi, S. *Annals of Nuclear Energy*, 2009, 36, (7), 974–987.

Cost and risk are two major competing criteria in maintenance optimization problems. If a plant is forced to shutdown because of accident or fear of accident happening, beside loss of revenue, it causes damage to the credibility and reputation of the business operation. In this paper a heuristic model for incorporating three compelling optimization criteria (i.e. risk, cost, and loss) into a single evaluation function is proposed. Such a model could be used in any evaluation engine of outage maintenance schedule optimizer. It is attempted to make the model realistic and to address the ongoing challenges facing a schedule planner in a simple and commonly understandable fashion. Two simple competing schedules for the NPP feedwater system are examined against the model. The results show that while the model successfully addresses the current challenges for outage maintenance optimization, it properly demonstrates the dynamics of schedule in regards to risk, cost, and losses endured by maintenance schedule, particularly when prolonged outage and lack of maintenance for equipments in need of urgent care are of concern.

10/01619 A US perspective on fast reactor fuel fabrication technology and experience. Part II: ceramic fuels

Burkes, D. E. *et al. Journal of Nuclear Materials*, 2009, 393, (1), 1–11.

This paper is the second part of a review focusing on the US experience with oxide, carbide, and nitride fast reactor fuel fabrication. Over 60 years of research in fuel fabrication by government, national laboratories, industry, and academia has culminated in a foundation of research and resulted in significant improvements to the technologies employed to fabricate these fuel types. This part of the review documents the current state of fuel fabrication technologies in the USA for each of these fuel types, some of the challenges faced by previous researchers, and how these were overcome. Knowledge gained from reviewing previous investigations will aid both researchers and policy makers in forming future decisions relating to nuclear fuel fabrication technologies.

10/01620 An evaluation of the severe accident management strategies for CANDU-6 type plants

Park, S.-Y. and Kim, S.-B. *Annals of Nuclear Energy*, 2009, 36, (9), 1340–1348.

This paper provides an evaluation of the mitigation effects for the severe accident management strategies of the Wolsong plants which are typical CANDU-6 type reactors. The evaluation includes the effect of the following six mitigation strategies: (1) injection into the primary heat transport system (PHTS), (2) injection into the calandria vessel, (3) injection into the calandria vault, (4) reduction of the fission product release, (5) control of the reactor building condition, (6) reduction of the reactor building hydrogen. The tested scenario is a loss of coolant accident with a small out-of-core break, and the thermal hydraulic and severe accident phenomenological analyses were implemented by using the ISAAC computer program. The calculation results show that the most effective means for a primary decay heat removal is a low pressure safety injection, that for a calandria vessel integrity is an end-shield cooling injection, and that for a reactor building integrity is a pressure control via local air coolers. Besides the above, the usefulness of each safety component was evaluated in this analysis.

10/01621 Economic analysis of hydride fueled BWR

Ganda, F. *et al. Nuclear Engineering and Design*, 2009, 239, (8), 1560–1570.

This study analyses the economic implications of designing BWR cores with hydride fuels instead of conventional oxide fuels. The economic analysis methodology adopted is based on the lifetime levelized cost of electricity. Bracketing values (1970 and 3010 $/kWe) are used for the overnight construction costs and for the power scaling factors (0.4 and 0.8) that correlate between a change in the capital cost to a change in the power level. It is concluded that a newly constructed BWR reactor could substantially benefit from the use of 10 × 10 hydride fuel bundles instead of 10 × 10 oxide fuel bundles design presently in use. The cost saving would depend on the core pressure drop constraint that can be implemented in newly constructed BWRs – it is between 2% and 3% for a core pressure drop constraint as of the reference BWR, between 9% and 15% for a 50% higher core pressure drop, and between 12% and 21% higher for close to 100% core pressure. The attainable cost reduction was found insensitive to the specific construction cost but strongly dependent on the power scaling factor. The cost advantage of hydride-fuelled cores as compared to that of the oxide reference core depends only weakly on the uranium and SWU prices, on the ‘per volume base’ fabrication cost of hydride fuels, and on the discount rate used. To be economically competitive, the uranium enrichment required for the hydride fuelled core needs to be around 10%.

10/01622 Evaluation method of nuclear nonproliferation credibility

Kwon, E.-H. and Ko, W. I. *Annals of Nuclear Energy*, 2009, 36, (7), 901–909.

This paper presents an integrated multicriteria analysis method for the quantitative evaluation of a state’s nuclear nonproliferation credibility level. Underscoring the implications of policy on the sources of political demand for nuclear weapons rather than focusing on efforts to restrict the supply of specific weapons technology from the ‘haves’ to the ‘have-nots’, the proposed methodology considers the political, social, and cultural dimensions of nuclear proliferation. This methodology comprises three steps: (1) identifying the factors that influence credibility formation and employing them to construct a criteria tree that will illustrate the relationships among these factors; (2) defining the weight coefficients of each criterion through pairwise comparisons of the analytical hierarchy process; and (3) assigning numerical scores to a state under each criterion and combining them with the weight coefficients in order to provide an overall assessment of the state. The functionality of this methodology is examined by assessing the current level of nuclear non-proliferation credibility of four countries: Japan, North Korea, South Korea, and Switzerland.

10/01623 Implementing first principles calculations of defect migration in a fuel performance code for UN simulations

Kotomin, E. A. *et al. Journal of Nuclear Materials*, 2009, 393, (2), 292–299.

Results are reported of first principles VASP supercell calculations of basic defect migration in UN nuclear fuels. The collinear interstitialcy mechanism of N migration is predicted to be energetically more favourable than direct [001] hops. It is also found that U and N vacancies have close migration energies, and O impurities accelerate migration of N vacancies nearby. These values are both in qualitative agreement with the effect of oxygen on the reduction of the activation energy for thermal creep reported in the literature, as well as in quantitative agreement with the experimental data when taking into account the uncertainties. The migration energies have been implemented in the thermal creep model of the TRANSURANUS fuel performance code. Therefore a concrete example is provided of how first principles computations can contribute directly to improve the design tools of advanced nuclear fuels, e.g. the predictions reveal a limited effect of oxygen on the thermo-mechanical performance of nitride fuels under fast breeder reactor normal operating conditions.

10/01624 Implications of the new national energy basic plan for nuclear waste management in Korea

Ko, W. I. and Kwon, E. *Energy Policy*, 2009, 37, (9), 3484–3488.

The Korean National Energy Committee has recently adopted a new national energy basic plan according to which the electricity generated by nuclear power plants is to increase from the current 35.5% of total electricity production to 59% by 2030. This large increase in nuclear power will inevitably accelerate the accumulation of spent fuel; if the direct disposal option is pursued, spent fuel arisings in Korea are expected to exceed 100,000 tHM in 2100. It is estimated that the country will require between 10–22 disposal sites, each with an area equal to the Gyeongju low- and intermediate-level radioactive waste (LILW) disposal site, to accommodate this amount of spent fuel. However, considering Korea’s geographic profile, securing this number of sites will be almost impossible, and will ultimately create a serious problem for the sustainability of nuclear energy in the country. In view of this dilemma, this paper recommends that the volume of Korean nuclear waste for disposal be significantly reduced, and offers sodium fast reactor (SFR)-based recycling as a potentially viable solution.

10/01625 Licensing of nuclear power plants: the case of Sweden in an international comparison

Michanek, G. and Söderholm, P. *Energy Policy*, 2009, 37, (10), 4086–4097.

Efficient power plant licensing procedures are essential for the functioning of deregulated electricity markets. The purpose of this paper is to review and analyse the licensing process for nuclear power plants in Sweden, and in part contrast the Swedish case with the corresponding approaches in a selection of other countries. This approach permits a discussion of how licensing processes can be altered and what the benefits and drawbacks of such changes are. The paper highlights and discusses a number of important legal issues and implications, including, for instance: (1) the role of political versus impartial decision-making bodies; (2) the tension between national policy goals and implementation at the local level; (3) public participation and access to justice; (4) consistency and clarity of the legal system; and (5) the introduction of license time limits.

10/01626 Present status of nuclear containments and ISI in Korea

Park, J. and Hong, J. *Progress in Nuclear Energy*, 2009, 51, (8), 761–768.

Since the first nuclear power plant started in commercial service in 1978 in Korea, 20 units have been operated and maintained, and most recently several units were under construction and planned to be constructed in order to meet electricity demand. The importance of nuclear containments always has been one of the hottest issues for the safety and protection of nuclear power plants. From 1970s to present year, various types of nuclear containments have been constructed until now. With the changes of times, nuclear containment systems have undergone a remarkable change, and finally a Korean standard nuclear power plant was defined. For those reasons, various regulatory issues, inspection technologies, technical requirements for periodic inspection have been applied differently depending on the specific nuclear containment types. In this study, the overall status of nuclear power plants, development stages of nuclear containment systems, and inservice inspections in Korea were researched.

06 ELECTRICAL POWER SUPPLY AND UTILIZATION

Scientific, technical

10/01627 A new fuzzy adaptive hybrid particle swarm optimization algorithm for non-linear, non-smooth and non-convex economic dispatch problem

Niknam, T. *Applied Energy*, 2010, 87, (1), 327–339.

Economic dispatch (ED) plays an important role in power system operation. ED problem is a non-smooth and non-convex problem when valve-point effects of generation units are taken into account. This paper presents an efficient hybrid evolutionary approach for solving the ED problem considering the valve-point effect. The proposed algorithm combines a fuzzy adaptive particle swarm optimization (FAPSO) algorithm with Nelder–Mead (NM) simplex search called FAPSO-NM. In the resulting hybrid algorithm, the NM algorithm is used as a local search algorithm around the global solution found by FAPSO at each iteration. Therefore, the proposed approach improves the performance of the FAPSO algorithm significantly. The algorithm is tested on two typical systems consisting of 13 and 40 thermal units whose incremental fuel cost functions take into account the valve-point loading effects.

10/01628 A PSO based unified power flow controller for damping of power system oscillations

Shayeghi, H. *et al. Energy Conversion and Management*, 2009, 50, (10), 2583–2592.

On the basis of the linearized Phillips–Herffron model of a single-machine power system, the authors approached the problem of selecting the best input control signal of the unified power flow controller (UPFC) and design optimal UPFC based damping controller in order to enhance the damping of the power system low frequency oscillations. The potential of the UPFC supplementary controllers to enhance the dynamic stability was evaluated. This controller is tuned to simultaneously shift the undamped electromechanical modes to a prescribed zone in the s-plane. The problem of robustly UPFC based damping controller is formulated as an optimization problem according to the eigenvalue-based multiobjective function comprising the damping factor, and the damping ratio of the undamped electromechanical modes to be solved using particle swarm optimization technique (PSO) that has a strong ability to find the most optimistic results. To ensure the robustness of the proposed damping controller, the design process takes into account a wide range of operating conditions and system configurations. The effectiveness of the proposed controller was demonstrated through eigenvalue analysis, non-linear time-domain simulation and some performance indices studies. The results analysis revealed that the tuned PSO-based UPFC controller using the proposed multiobjective function has an excellent capability in damping power system low frequency oscillations and enhances the dynamic stability of the power systems. Moreover, the system performance analysis under different operating conditions show that the δ_E-based controller is superior to the m_B-based controller.

10/01629 An exploratory game-theoretic analysis of biomass electricity generation supply chain

Nasiri, F. and Zaccour, G. *Energy Policy*, 2009, 37, (11), 4514–4522.

This study proposes a game-theoretic approach to model and analyse the process of utilizing biomass for power generation considering three players: distributor, facility developer, and participating farmer. The Nash equilibrium of the sequential game is characterized and its features discussed. Special attention is devoted to the analysis of the impact of incentives and initial target on the equilibrium, in which the biomass is part of electricity production.

10/01630 An improved harmony search algorithm for power economic load dispatch

dos Santos Coelho, L. and Mariani, V.C. *Energy Conversion and Management*, 2009, 50, (10), 2522–2526.

A meta-heuristic algorithm called harmony search (HS), mimicking the improvisation process of music players, has been recently developed. The HS algorithm has been successful in several optimization problems. The HS algorithm does not require derivative information and uses stochastic random search instead of a gradient search. In addition, the HS algorithm is simple in concept, few in parameters, and easy in implementation. This paper presents an improved harmony search (IHS) algorithm based on exponential distribution for solving economic dispatch problems. A 13-unit test system with incremental fuel cost function taking into account the valve-point loading effects is used to illustrate the effectiveness of the proposed IHS method. Numerical results show that the IHS method has good convergence property. Furthermore, the generation costs of the IHS method are lower than those of the classical HS and other optimization algorithms reported in recent literature.

10/01631 Applying wavelet entropy principle in fault classification

El Safty, S. and El-Zonkoly, A. *International Journal of Electrical Power & Energy Systems*, 2009, 31, (10), 604–607.

The ability to detect and classify the type of fault plays a great role in the protection of power system. This procedure is required to be precise with no time consumption. In this paper detection of fault type has been implemented using wavelet analysis together with wavelet entropy principle. The simulation of power system is carried out using PSCAD/EMTDC. Different types of faults were studied obtaining various current waveforms. These current waveforms were decomposed using wavelet analysis into different approximation and details. The wavelet entropies of such decompositions are analysed reaching a successful methodology for fault classification. The suggested approach is tested using different fault types and proven successful identification for the type of fault.

10/01632 Conceptual model and evaluation of generated power and emissions in an IGCC plant

Pérez-Fortes, M. *et al. Energy*, 2009, 34, (10), 1721–1732.

This work develops a design and operation support tool for an integrated gasification combined cycle (IGCC) power plant, which allows the efficiency and environmental issues of alternative process designs and feedstock to be assessed. The study is based on a conceptual model of an IGCC plant, validated with data from the ELCOGAS power plant in Spain. The layout of the model includes an air separation unit (ASU), a pressurized entrained flow (PRENFLO) gasifier, a series of purification gas units (venturi scrubber, sour water steam stripper, COS hydrolysis reactor, MDEA absorber columns and a sulfur recovery Claus plant), a heat recovery steam generator (HRSG) and a combined cycle (CC) system. It comprises steady state models. One of the purposes of this work is to analyse the feasibility of coal co-gasification using waste materials; specifically petcoke and olive pomace (orujillo) are considered here. The model has been developed in Aspen Hysys. It uses electrolyte models that have been implemented in Aspen Plus which are connected to Aspen Hysys by means of artificial neural networks models. Results of the model's, gas composition and generated power, are in agreement with the industrial data.

10/01633 Effects of technological learning on future cost and performance of power plants with CO_2 capture

van den Broek, M. *et al. Progress in Energy and Combustion Science*, 2009, 35, (6), 457–480.

This paper demonstrates the concept of applying learning curves in a consistent manner to performance as well as cost variables in order to assess the future development of power plants with CO_2 capture. An existing model developed at Carnegie Mellon University, which had provided insight into the potential learning of cost variables in power plants with CO_2 capture, is extended with learning curves for several key performance variables, including the overall energy loss in power plants, the energy required for CO_2 capture, the CO_2 capture ratio (removal efficiency), and the power plant availability. Next, learning rates for both performance and cost parameters were combined with global capacity projections for fossil-fired power plants to estimate future cost and performance of these power plants with and without CO_2 capture. The results of global learning are explicitly reported, so that they can be used for other purposes such as in regional bottom-up models. Results of this study show that IGCC with CO_2 capture has the largest learning potential, with significant improvements in efficiency and reductions in cost between 2001 and 2050 under the condition that around 3100 GW of combined cycle capacity is installed worldwide. Furthermore, in a scenario with a strict climate policy, mitigation costs in 2030 are 26, 11, 19 €/t (excluding CO_2 transport and storage costs) for NGCC, IGCC, and PC power plants with CO_2 capture, respectively, compared to 42, 13, and 32 €/t in a scenario with a limited climate policy. Additional results are presented for IGCC, PC, and NGCC plants with and without CO_2 capture, and a sensitivity analysis is employed to show the impacts of alternative assumptions on projected learning rates of different systems.

10/01634 Electrical analysis of a hybrid photovoltaic-hydrogen/fuel cell energy system in Denizli, Turkey

Cetin, E. *et al. Energy and Buildings*, 2009, 41, (9), 975–981.

In recent years, hybrid photovoltaic-hydrogen/fuel cell energy systems have been popular as energy production systems that are clean, environmental-friendly, modular, and independent from fossil fuels. In February 2007, a clean energy research facility consisting of a 5 kWp photovoltaic system and a 2.4 kWp hydrogen-fuel cell system was built to investigate these energy production technologies at Pamukkale University in Denizli, Turkey. In this hybrid energy system, electricity is generated by photovoltaic panels. Generated electrical energy is stored chemically in batteries and metal hydride hydrogen canisters. Hydrogen electrolysed from water is transformed to DC electrical energy by two fuel cells in the case of its necessity. DC electricity produced by photovoltaic panels and fuel cells is converted to AC by two inverters for the requirements of the building. In this study, an electrical energy analysis of the building, in terms of energy efficiency, harmonics, voltage changes, voltage and current sags, voltage and current swells, transients, power outage, frequency changes, etc., is performed to evaluate the power quality of the hybrid energy system. In addition, some measurements such as insulation resistance, loop impedance, line impedance, grounding resistance, and specific resistance of the ground are measured to obtain the electrical characteristics of the system.

10/01635 Electrolysers as a load management mechanism for power systems with wind power and zero-carbon thermal power plant

Troncoso, E. and Newborough, M. *Applied Energy*, 2010, 87, (1), 1–15.

For an isolated power system the deployment of a large stock of electrolysers was investigated as a means for increasing the penetrations of wind power plants and zero-carbon thermal power plants. Consideration was given to the sizing and utilization of an electrolyser stock for three electrolyser implementation cases and three operational strategies, installed capacity ranges of 20–100% for wind power and 10–35% for zero-carbon thermal power plant (as proportions of the power system's maximum electrical demand) were investigated. Relative to wind-hydrogen alone, hydrogen yields are substantially increased especially on low-wind days. The average load placed on fossil-fuelled power plant was substantially decreased (while achieving a virtually flat load profile) and the carbon intensity of electricity could be reduced to values of $<0.1\,\mathrm{kg}\ \mathrm{CO_2/kWh_e}$. The trade-offs between the carbon intensity of the electricity delivered, the carbon intensity of the hydrogen produced and the daily hydrogen yield were explored. For example (on the variable wind day for Strategy C with respective wind power and zero-carbon thermal power penetrations of 100% and 35%), if the carbon intensity of hydrogen was relaxed from 0 to $3\,\mathrm{kg}\ \mathrm{CO_2/kg}\ \mathrm{H_2}$, the hydrogen yield could be increased from 435 tonnes to 1115 tonnes (which is the energy equivalent of 120% of consumer demand for electricity on that day). The findings suggest that the deployment of electrolysers on both the supply and demand-side of the power system can contribute nationally significant amounts of zero or low-carbon hydrogen without exceeding the power system's current maximum system demand.

10/01636 Fixed switching frequency applied in single-phase boost AC to DC converter

Chen, T.-C. *et al. Energy Conversion and Management*, 2009, 50, (10), 2659–2664.

The fixed switching frequency control for a single-phase boost AC to DC converter to achieve a sinusoidal line current and unity power factor is proposed in this paper. The relation between the line current error and the fixed switching frequency was developed. For a limit line current error, the minimum switching frequency for a boost AC to DC converter can be achieved. The proposed scheme was implemented using a 32-bit digital signal processor TMS320C32. Simulations and experimental results demonstrate the feasibility and fast dynamic response of the proposed control strategy.

10/01637 On feasibility boundaries of electrical power grids in steady state

Krause, O. *et al. International Journal of Electrical Power & Energy Systems*, 2009, 31, (9), 437–444.

Both the coordination of international energy transfer and the integration of a rapidly growing number of decentralized energy resources (DER) throughout most countries cause novel problems for avoiding voltage band violations and line overloads. Traditional approaches are typically based on global off-line scheduling under globally available information and rely on iterative procedures that can guarantee neither convergence nor execution time. This study focuses on operational limitation problems in power grids based on widely dispersed (renewable) energy sources. The authors introduce an extension to the DEZENT algorithm, a multi-agent based coordination system for DER that allows for the feasibility verification in constant and predetermined time. A numerical example is provided showing the legitimacy of the approach and ongoing and future work regarding its implementation and utilization is discussed.

10/01638 Optimal design of binary cycle power plants for water-dominated, medium-temperature geothermal fields

Franco, A. and Villani, M. *Geothermics*, 2009, 38, (4), 379–391.

Exploitation of lower temperature, water-dominated geothermal fields is analysed, and a methodology for optimizing geothermal binary plants is discussed. The geothermal fluid inlet temperatures considered are in the 110–160 °C range, while the return temperature of the brine is assumed to be between 70 and 100 °C. The analysis shows that the brine specific consumption, ranging from 20 to $120\,\mathrm{kg\,s^{-1}}$ for each net MW produced, and the efficiency of the plants, ranging from 20% to 45% in terms of Second Law efficiency, are dictated mainly by the combination of the brine inlet temperature, the brine rejection temperature and the energy conversion cycle being used. For given operating conditions and with correct matching between working fluid and energy conversion cycle, it is possible to obtain very similar performances in a number of different cases. It is shown that optimization of the plant can yield improvements of up to 30–40% in terms of reduction of brine specific consumption compared to conventional design.

10/01639 Optimization strategy for element sizing in hybrid power systems

del Real, A. J. *et al. Journal of Power Sources*, 2009, 193, (1), 315–321.

This paper presents a procedure to evaluate the optimal element sizing of hybrid power systems. In order to generalize the problem, this work exploits the 'energy hub' formulation previously presented in the literature, defining an energy hub as an interface among energy producers, consumers and the transportation infrastructure. The resulting optimization minimizes an objective function which is based on costs and efficiencies of the system elements, while taking into account the hub model, energy and power constraints and estimated operational conditions, such as energy prices, input power flow availability and output energy demand. The resulting optimal architecture also constitutes a framework for further real-time control designs. Moreover, an example of a hybrid storage system is considered. In particular, the architecture of a hybrid plant incorporating a wind generator, batteries and intermediate hydrogen storage is optimized, based on real wind data and averaged residential demands, also taking into account possible estimation errors. The hydrogen system integrates an electrolyser, a fuel cell stack and hydrogen tanks. The resulting optimal cost of such hybrid power plant is compared with the equivalent hydrogen-only and battery-only systems, showing improvements in investment costs of almost 30% in the worst case.

10/01640 Partial O_2-fired coal power plant with post-combustion CO_2 capture: a retrofitting option for CO_2 capture ready plants

Doukelis, A. *et al. Fuel*, 2009, 88, (12), 2428–2436.

In the work presented in this paper, an alternative process concept that can be applied as retrofitting option in coal-fired power plants for CO_2 capture is examined. The proposed concept is based on the combination of two fundamental CO_2 capture technologies, the partial oxyfuel mode in the furnace and the post-combustion solvent scrubbing. A $330\,\mathrm{MW_{el}}$ Greek lignite-fired power plant and a typical $600\,\mathrm{MW_{el}}$ hard coal plant have been examined for the process simulations. In a retrofit application of the ECO-Scrub technology, the existing power plant modifications are dominated by techno-economic restrictions regarding the boiler and the steam turbine islands. Heat integration from processes (air separation, CO_2 compression and purification and the flue gas treatment) can result in reduced energy and efficiency penalties. In the context of this work, heat integration options are illustrated and main results from thermodynamic simulations dealing with the most important features of the power plant with CO_2 capture are presented for both reference and retrofit case, providing a comparative view on the power plant net efficiency and energy consumptions for CO_2 capture. The operational characteristics as well as the main figures and diagrams of the plant's heat balances are included.

10/01641 Performance of an oxy-fuel combustion CO_2 power cycle including blade cooling

Fiaschi, D. *et al. Energy*, 2009, 34, (12), 2240–2247.

The guiding idea behind oxy-fuel combustion power cycles is guaranteeing a high level of performance as can be obtained by today's advanced power plants, together with CO_2 separation in conditions ready for transport and final disposal. In order to achieve all these goals, oxy-combustion – allowing CO_2 separation by simple cooling of the combustion products – is combined with large heat recovery and staged expansions/compressions, making use of new components, technology and materials upgraded from modern gas turbine engines. In order to provide realistic results, the power plant performance should include the effects of blade cooling. In this work an advanced cooled expansion model has been included in the model of the MATIANT cycle in order to assess the effects of blade cooling on the cycle efficiency. The results show that the penalty in efficiency due to blade cooling using steam from the heat recovery boiler is about 1.4 percentage points, mainly due to the reheat of the steam, which, on the other hand, leads to an improvement in specific work of about 6%.

10/01642 Preparation and characterization of polypyrrole films for three-dimensional micro supercapacitor

Sun, W. and Chen, X. *Journal of Power Sources*, 2009, 193, (2), 924–929.

As electro-active electrodes for supercapacitors, micro polypyrrole (PPy) films doping with ClO_4^- (PPy_{ClO_4}) and Cl^- (PPy_{Cl}) are prepared on Ni layers modified three-dimensional (3D) structures in Si substrates. The key process to fabricate the 3D structures is high-aspect-ratio deep reactive ion etching, which result in significant increase of available surface area. Homogeneous conformal Ni layers and PPy films are deposited on the 3D structures by electroless plating and electropolymerization, respectively. The supercapacitor properties of PPy films are investigated by using cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS) and galvanostatic charge/discharge with three-electrode system in NaCl solution. It is shown that doping with ClO_4^- results in ideal supercapacitor behaviours with rectangle-like CV shapes at scan rates from 5 to 200 mV s^{-1}, linear galvanostatic charge/discharge curves at current loads from 0.5 to 2 mA and stable cyclic property. However, doping with Cl^{-} gives rise to non-ideal properties of supercapacitor. SEM of the PPy$_{\mathrm{ClO_4}}$ shows that the surface of the PPy$_{\mathrm{ClO_4}}$ electrode is smooth and the thickness of the PPy$_{\mathrm{ClO_4}}$ film is about 2.5 μm. The geometric capacitance of PPy$_{\mathrm{ClO_4}}$ is calculated as 0.030 F cm^{-2} from CV at scan rate of 100 mV s^{-1}, 0.023 F cm^{-2} from EIS and 0.027 F cm^{-3} from galvanostatic discharge at 1 mA cm^{-2} current density.

10/01643 Pricing power outages in the Netherlands

Baarsma, B. E. and Hop, J. P. *Energy*, 2009, 34, (9), 1372–1377.

In most Western countries, the power grid provides electricity more than 99% of the time. To maintain reliability at such high levels, energy companies have to continually invest in electric transmission and distribution systems. Since customers of electricity cannot switch from one distribution network to another, no economic incentive exists that matches the supplied reliability to customer preferences. Either under- or over-investment in reliability may thus result. In order to introduce market-like incentives, the Dutch Energy Regulator introduced a regulatory system based on the (perceived) costs of power outages. An essential ingredient of the regulation is the cost of a power outage of a particular duration (i.e. 1 minute). This paper measures these outage cost by using conjoint analysis. The social cost of the present Dutch level of reliability – that is, one outage of two hours every four years – is €2.80 on average for every household, and €33.10 on average for every SME firm. The total costs to Dutch society are almost €50 million.

10/01644 Proposed hybrid superconducting fault current limiter for distribution systems

Elmitwally, A. *International Journal of Electrical Power & Energy Systems*, 2009, 31, (10), 619–625.

In this paper, a new hybrid fault current limiter is proposed for primary distribution systems. It incorporates a high temperature superconducting element in parallel with other two branches. The first is an inductive impedance to share the fault current with. The second branch is a gate-turn-off thyristor switch controlled to work in either of two modes. For the main mode, it controls the temperature of the superconducting element and protect it against damaging excessive heating. Instead, it keeps the device applicable without that superconducting element in the auxiliary operation mode. The design, control and operation of the device is addressed. Its performance in 11 kV distribution systems with DG is investigated. The factors affecting the device behaviour for different scenarios are explored.

10/01645 Residential application of internal combustion engine based cogeneration in cold climate – Canada

Aussant, C. D. *et al. Energy and Buildings*, 2009, 41, (12), 1288–1298.

The objectives of this work are to model a group of test case houses using a high-resolution building simulation program, to evaluate the efficiency of internal combustion engine (ICE)-based cogeneration and to determine the economical (in terms of fuel cost) impact of using ICE-based cogeneration systems for residential use. The performance in terms of electrical and CHP efficiencies of the ICE-based cogeneration systems in Canada were investigated and it was determined that the performance of the ICE-based cogeneration system is dependent on the thermal and electrical loads of the house, on climate, especially the severity and duration of the heating season, and on the constructional characteristics of the house. Although the annual fuel cost of the household would increase, the ICE-based cogeneration systems can provide savings in various aspects regarding electricity production and distribution.

10/01646 Structural vulnerability of energy distribution systems: incorporating infrastructural dependencies

Helseth, A. and Holen, A. T. *International Journal of Electrical Power & Energy Systems*, 2009, 31, (9), 531–537.

In this paper a novel method for assessing the structural vulnerability of two coupled energy distribution systems is presented. The co-existing of an electric power distribution system and a district heating system is described and modelled, under the assumption that the operation of the district heating system is directly dependent on electric power. The structural vulnerability of the two systems subject to single failures or a set of simultaneous failures in the power system is found. Thus, the consequences of power system failures for the energy supply as a whole are quantified.

Economics, policy, supplies, forecasts

10/01647 A combined Markov-chain and bottom-up approach to modelling of domestic lighting demand

Widén, J. *et al. Energy and Buildings*, 2009, 41, (10), 1001–1012.

Detailed simulations of distributed generation in residential areas have prompted the need for improved models of domestic electricity demand that are able to reproduce important features of real household loads. The high share and temporal variability of the lighting demand make it of special interest, in particular when the models are to be used in simulations of distributed photovoltaics (PV), which to a high degree is negatively correlated with the lighting demand. In this paper, a stochastic bottom-up model based on domestic occupancy patterns and data on daylight availability is presented. A three-state non-homogeneous Markov chain is used for generation of occupancy patterns and a conversion model transforms occupancy patterns to lighting demand, with respect to the daylight level. Markov-chain transition probabilities are determined from a detailed set of time-use (TU) data in Swedish households and the parameters in the occupancy-to-lighting conversion model are adjusted to make the resulting load curves fit recent measurements on aggregate population level. The performance of the model is analysed by comparison of simulated demand to measured lighting demand. It is concluded that for both individual households and aggregate demand, all relevant features of measured demand are realistically reproduced.

10/01648 A grid operation model: resource demand for an adequate incident management in high-, medium-, and low-voltage grids

Guarisco, M. *et al. International Journal of Electrical Power & Energy Systems*, 2009, 31, (9), 504–511.

Based on the regulation of grid fees and the regulatory requirements on the quality of supply, grid operators attempt to find an optimal balance between costs and quality of supply. One main aspect of the quality of supply is the non-availability of supply, which strongly depends on the duration of the restoration process after incidents and therefore on the availability of resources. Focusing on the operational processes after incidents in low-, medium-, and high-voltage grids, this paper presents a detailed grid operation model which allows to quantify the relation between the configuration of resources and the corresponding costs and quality of supply. To assess the ‘risk’ of incidents with no interruption of supply, the ‘power-at-risk’ is introduced. Depending on legal, regulatory, or strategic requirements, the model allows to evaluate and compare different configurations of resources and the resulting quality of supply.

10/01649 A paper on the unsettled question of Turkish electricity market: balancing and settlement system (Part I)

Erdogdu, E. *Applied Energy*, 2010, 87, (1), 251–258.

Turkish electricity market law (EML) came into force in 2001 aiming at establishing a financially strong, stable, transparent and competitive electricity market based on bilateral contracts. Also, a balancing and settlement system (BSS) was put into practice in November 2004 to create a market where uncontracted generation can be traded, and actual implementation of the BSS started on 1 August 2006 following a 21-month virtual implementation period. However, BSS has always been criticized from its beginning as transferring excessive profits to private generation companies. The present paper analyses the implementation of BSS and argues that current BSS not only undermines the healthy development of the electricity market in Turkey but also prevents power investments due to uncertainties it created. It concludes that since the inconsistency between the objectives of EML and results of BSS in practice is obvious, Turkish policy makers need to modify current electricity market policy in line with suggestions presented in the paper.

10/01650 Aggregate electricity demand in South Africa: conditional forecasts to 2030

Inglesi, R. *Applied Energy*, 2010, 87, (1), 197–204.

In 2008, South Africa experienced a severe electricity crisis. Domestic and industrial electricity users had to suffer from blackouts all over the country. It is argued that partially the reason was the lack of research on energy, locally. However, it has been argued by Eskom, the national electricity supplier, that the lack of capacity can only be solved by building new power plants. The objective of this study is to specify the variables that explain the electricity demand in South Africa and to forecast electricity demand by creating a model using the Engle–Granger methodology for co-integration and error correction models. By producing reliable results, this study will make a significant contribution that will improve the *status quo* of energy research in South Africa. The findings indicate that there is a long-run relationship between electricity consumption and price as well as economic growth/income. The last few years in South Africa, price elasticity was rarely taken into account because of the low and decreasing prices in the past. The short-run dynamics of the system are affected by population growth, too. After the energy crisis Eskom has been searching for substantial funding in order to build new power plants which will help with the envisaged lack of capacity that the company experienced. By using two scenarios for the future of growth, this study shows that the electricity demand will drop substantially due to the price policies agreed – until now – by Eskom and the National Energy Regulator South Africa that will affect the demand for some years.

10/01651 Are electricity prices affected by the US dollar to Euro exchange rate? The Spanish case

Muñoz, M. P. and Dickey, D. A. *Energy Economics*, 2009, 31, (6), 857–866.

The objective of this paper is to investigate the relationships between Spanish electricity spot prices and the US dollar/euro (US$/€) exchange rate during the period 2005–2007, taking into account the study of the association between dollar and oil prices, in order to better understand the evolution of the former over time. The first finding in this study is that Spanish electricity spots prices, the US$/€ exchange rate and oil prices are cointegrated; therefore there is a long-run equilibrium relationship between the three variables. Short-run relationships have been detected between oil prices and Spanish electricity prices and US$/€ exchange rate in the sense that Spanish electricity prices and US$/€ exchange rate are affected by oil prices in the short run. There is a transmission of volatility between US$/€ exchange rate and oil prices to Spanish electricity prices; so although Spanish electricity prices are not affected in level by the movements of US$/€ exchange rate, they are in volatility. In this kind of scenario the conclusions confirm that for countries so dependent on external causes as Spain, one possible solution for guarantying the energy security would be the promotion of the renewable energies. Therefore the impact in the internal expenses of the cost of installation and generation of green energies cannot be ignored so there must be a balance between the increase in renewables and the reasonable market price of the electricity.

10/01652 Congestion management considering voltage security of power systems

Esmaili, M. *et al. Energy Conversion and Management*, 2009, 50, (10), 2562–2569.

Congestion in a power network is turned up due to system operating limits. To relieve congestion in a deregulated power market, the system operator pays to market participants, GENCOs and DISCOs, to alter their active powers considering their bids. After performing congestion management, the network may be operated with a low security level because of hitting some flows their upper limit and some voltages their lower limit. In this paper, a novel congestion management method based on the voltage stability margin sensitivities is introduced. Using the proposed method, the system operator so alleviates the congestion that the network can more retain its security. The proposed method not only makes the system more secure after congestion management than other methods already presented for this purpose but also its cost of providing security is lower than the earlier methods. Test results of the proposed method along with the earlier ones on the New-England test system elaborate the efficiency of the proposed method from the viewpoint of providing a better voltage stability margin and voltage profile as well as a lower security cost.

10/01653 Coordinated preventive maintenance scheduling of GENCO and TRANSCO in restructured power systems

Geetha, T. and Shanti Swarup, K. *International Journal of Electrical Power & Energy Systems*, 2009, 31, (10), 626–638.

Preventive maintenance of generating units and lines, in a competitive electric energy environment is proposed. Inclusion of transmission constraints and forced outage rates, over a specified operational period is considered. For generator maintenance the objective of the ISO is to maintain adequate level of reliability throughout the operational period, for which Bender's decomposition technique is used. The objective of the GENCO is to maximize profit or to minimize loss in profit, for which transmission constrained price based unit commitment (TCPBUC), based on Lagrangian relaxation method is used. Bender's decomposition technique is used for line maintenance, with adequate level of reliability. A coordinating technique using penalty factors is incorporated to obtain convergence of the conflicting objectives. The transmission constraints are modelled using dc sensitivity factors. Detailed case studies of six-bus systems and IEEE RTS system are presented and discussed.

10/01654 Core business concentration vs. corporate diversification in the US electric utility industry: synergy and deregulation effects

Sueyoshi, T. *et al. Energy Policy*, 2009, 37, (11), 4583–4594.

Many economists have considered that there are similarities between electricity and gas services in the US electric utility industry. Hence, they expect a synergy effect between them. However, the two businesses do not have technology similarities at the level that the gas service produces a synergy effect with electricity. To examine whether there is a synergy effect of corporate diversification in the industry, the authors compare electricity-specialized firms with diversified utility firms in terms of their financial performance and corporate value. The comparison indicates that core business concentration is more effective for electric utility firms than corporate diversification under the current US deregulation policy.

10/01655 Cost efficiency and optimal scale of electricity distribution firms in Taiwan: an application of metafrontier analysis

Huang, Y.-J. *et al. Energy Economics*, 2010, 32, (1), 15–23.

This paper analyses the cost efficiency and optimal scale of Taiwan's electricity distribution industry. Due to the substantial difference in network density, firms may differ widely in production technology. The stochastic metafrontier approach was used to estimate the cost efficiency of 24 distribution units during the period 1997–2002. Empirical results found that the average cost efficiency is over-estimated using the traditional stochastic frontier model, especially for low-density regions. The average cost efficiency of the high-density group was significantly higher than that of the low density group as it benefits from network economies. This study also calculated both short-term and long-term optimal scales of electricity distribution firms, lending policy implications for the deregulation of the electricity distribution industry.

10/01656 Efficient investment signals for distributed generation

Vogel, P. *Energy Policy*, 2009, 37, (9), 3665–3672.

Distributed generation units are desirable from an environmental point of view but also have an impact on the costs of electricity grids at the distribution and transmission level. Therefore, investment planning has to consider all benefits and costs of DG to build DG sources at sites where they are economically efficient. Unfortunately, this is not an easy task in an unbundled industry where distribution and generation of electricity are not planned by one single institution. For this reason, this article analyses possible policy options for giving incentives to distributed generation and focuses on the long-term investment signals related to DG.

10/01657 Employment benefits of electricity generation: a comparative assessment of lignite and natural gas power plants in Greece

Tourkolias, C. *et al. Energy Policy*, 2009, 37, (10), 4155–4166.

This paper aims at developing an integrated approach for estimating the employment benefits associated with power-generation technologies. The proposed approach exploits the input–output methodology for estimating the direct, indirect and induced employment effects associated with the energy project in question, as well as two different valuation techniques, namely the 'opportunity cost of labour' approach and the 'public expenditures' approach, for expressing these effects in monetary terms. This framework has been implemented to estimate the employment benefits resulting from the development of a lignite-fired and a natural gas-fired power plant in Greece, taking into account all the stages of the corresponding fuel cycles that are undertaken domestically. The results of the analysis clearly show that lignite-fired electricity generation results in significant employment benefits amounting to 2.9–3.5 €/MWh in the basic scenario. On the other hand, the employment benefits associated with the examined natural gas unit were estimated at 0.4–0.6 €/MWh in the basic scenario. It is also worth mentioning that the significant environmental externalities of the lignite-fired electricity in Greece that have been presented in a number of studies can only be partially compensated by the estimated employment benefits.

10/01658 Expanding opportunities: strategic buying of utilities in new EU member states

LaBelle, M. *Energy Policy*, 2009, 37, (11), 4672–4678.

During the 1990s, limited investment opportunities in Western Europe, the opening of the energy markets in Eastern Europe, and the future expansion of the European Union (EU) prompted an expansionist strategy by energy companies from the original EU member states. In this paper, the acquisition and divestiture activities and strategies of utilities from France and Germany are analysed in the context of the 2004 and 2007 EU enlargements. Through quantitative and qualitative data analysis, including the development of two case studies, the strategy for expansion and evolution in new member states is examined. The results demonstrate a concerted effort to establish economies of scale through ownership of distribution companies. A change in strategy occurs as these privatization opportunities disappear. Generation and trading activity become the growth area for these companies as electricity supply becomes another factor that can contribute to the economies of scale. Recent EU-supported efforts towards regionalization of electricity markets, positions these companies well due to their strong regional presence. This paper will explore these issues in the context of ownership and geographic distribution.

10/01659 Feasibility and flexibility for a trigeneration system

Lai, S. M. and Hui, C. W. *Energy*, 2009, 34, (10), 1693–1704.

A trigeneration system, which produces heat, cold and electricity simultaneously, is generally designed based on the nominal condition. However, the utility demands are seldom fixed and they are usually changing in periodical manner with the climate and the human activities. These demand changes make the system design difficult. To ensure operability, the system should be feasible and flexible to tackle such demand variations. Over-sizing, thermal storage and flexibility re-allocation can be used to improve a trigeneration system's feasibility and flexibility. These techniques may enlarge the feasible operating region, change and shift the expected utility production demands and interchange between different generation capabilities according to the demand requirements. As a result, the process feasibility and flexibility can be improved. With feasible operation ensured, process flexibility can be considered under economic trade-offs. A flexible design with reasonable investment and operating costs provides additional benefits to cater demand changes in the future. In this study, process flexibility and feasibility characteristics are proposed and evaluated from a new perspective. These are demonstrated in the trigeneration system design with a pre-defined structure to handle periodical utility demand deviations in a commercial building complex.

10/01660 Government procurement of peak capacity in the New Zealand electricity market

Poletti, S. *Energy Policy*, 2009, 37, (9), 3409–3417.

This paper analyses the impact of government procurement of reserve electricity generation capacity on the long-run equilibrium in the electricity market. The approach here is to model the electricity market in a context where the supply companies have market power. The model is then used to analyse the impact of government direct supply of peak capacity on the market. The authors found that the firms build less peak-generation capacity when the government procures peak generating capacity. The long-run equilibrium with N firms and government capacity of K_G results in an increase of total peak generation capacity of $K_G/(N+1)$ compared to the long-run equilibrium with no government capacity. Supply disruptions of baseline capacity during the peak time period are also considered. It is found that peak prices do not go up any further with (anticipated) supply disruptions. Instead the entire cost of the extra peakers is borne by customers on traditional meters and off-peak customers who face real-time pricing.

10/01661 Improvements in current European network regulation to facilitate the integration of distributed generation

Frías, P. *et al. International Journal of Electrical Power & Energy Systems*, 2009, 31, (9), 445–451.

This paper analyses how traditional regulation of distribution system operators (DSO) has to be improved to accommodate higher levels of distributed generation (DG). In addition, new economic signals to be given to DG operators for system efficient integration are proposed. Regulatory improvements at the European level are recommended. Recommendations are centred on schemes for DSO revenue compensation to consider incremental network costs due to DG, distribution network planning integrating DG, and DSO incentives for improving network performance with active integration of DG. Regarding DG economic signals, recommendations are focused on the design of DG connection and use-of-system charges, the revision of current DG support mechanisms based on flat feed-in tariffs, and the provision of ancillary services by DG for network voltage management, power flow controls and islanding.

10/01662 Job creation due to nuclear power resurgence in the United States

Kenley, C. R. *et al. Energy Policy*, 2009, 37, (11), 4894–4900.

The recent revival of global interest in the next generation of nuclear power reactors is causing a re-examination of the role of nuclear power in the United States. This renewed interest has led to questions regarding the capability and capacity of current US industries to support a renewal of nuclear power plant deployment. Key among the many questions currently being asked is what potential exists for the creation of new jobs as a result of developing and operating these new plants? Idaho National Laboratory and Bechtel Power Corporation collaborated to perform a Department of Energy-sponsored study that evaluated the potential for job creation in the United States should these new next generation nuclear power plants be built. The study focused primarily on providing an initial estimate of the numbers of new manufacturing jobs that could be created, including those that could be repatriated from overseas, resulting from the construction of these new reactors. In addition to the growth in the manufacturing sector, the study attempted to estimate the potential increase in construction trades necessary to accomplish the new construction.

10/01663 Long term electric load forecasting based on particle swarm optimization

AlRashidi, M. R. and EL-Naggar, K. M. *Applied Energy*, 2010, 87, (1), 320–326.

This paper presents a new method for annual peak load forecasting in electrical power systems. The problem is formulated as an estimation problem and presented in state space form. A particle swarm optimization is employed to minimize the error associated with the estimated model parameters. Actual recorded data from Kuwaiti and Egyptian networks are used to perform this study. Results are reported and compared to those obtained using the well known least error squares estimation technique. The performance of the proposed method is examined and evaluated. Finally, estimated model parameters are used in forecasting the annual peak demands of Kuwait network.

10/01664 Market clearing of joint energy and reserves auctions using augmented payment minimization

Amjady, N. *et al. Energy*, 2009, 34, (10), 1552–1559.

This paper presents the market clearing of joint energy and reserves auctions and its mathematical formulation, focusing on a possible implementation of the payment cost minimization (PCM). It also discusses another key point in debate: whether a market clearing algorithm should minimize offer costs or payment costs? An aggregated simultaneous market clearing approach is proposed for provision of ancillary services as well as energy, which is in the form of mixed integer non-linear programming (MINLP) formulation. In the MINLP formulation of the market clearing process, the objective function (payment cost or offer cost) are optimized while meeting AC power flow constraints, system reserve requirements and lost opportunity cost (LOC) considerations. The model is applied to the IEEE 24-bus reliability test system (IEEE 24-bus RTS), and simulation studies are carried out to examine the effectiveness of each objective function.

10/01665 Market power in the Nordic electricity wholesale market: a survey of the empirical evidence

Fridolfsson, S.-O. and Tangerås, T. P. *Energy Policy*, 2009, 37, (9), 3681–3692.

This study reviews the recent empirical research assessing market power on the Nordic wholesale market for electricity, Nord Pool. The studies find no evidence of systematic exploitation of system level market power on Nord Pool. Local market power arising from transmission constraints seems to be more problematic in some price areas across the Nordic countries. Market power can manifest itself in a number of ways that have so far escaped empirical scrutiny. The authors discuss investment incentives, vertical integration and buyer power, as well as withholding of base-load (nuclear) capacity.

10/01666 Online short-term solar power forecasting

Bacher, P. *et al. Solar Energy*, 2009, 83, (10), 1772–1783.

This paper describes a new approach to online forecasting of power production from PV systems. The method is suited to online forecasting in many applications and in this paper it is used to predict hourly values of solar power for horizons of up to 36 h. The data used are 15-min observations of solar power from 21 PV systems located on rooftops in a small village in Denmark. The suggested method is a two-stage method where first a statistical normalization of the solar power is obtained using a clear sky model. The clear sky model is found using statistical smoothing techniques. Then forecasts of the normalized solar power are calculated using adaptive linear time series models. Both autoregressive (AR) and AR with exogenous input (ARX) models are evaluated, where the latter takes numerical weather predictions (NWPs) as input. The results indicate that for forecasts up to 2 h ahead the most important input is the available observations of solar power, while for longer horizons NWPs are the most important input. A root mean square error improvement of around 35% is achieved by the ARX model compared to a proposed reference model.

10/01667 Renewable energy issues and electricity production in Middle East compared with Iran

Mostafaeipour, A. and Mostafaeipour, N. *Renewable and Sustainable Energy Reviews*, 2009, 13, (6–7), 1641–1645.

This paper analyses the renewable energy issues and electricity production in Middle East compared with Iran. Nevertheless, the use of renewable energy has started to be an interesting issue for people and also governments in Middle East, especially in Iran where all different types of renewable energy sources are available and also possible to implement for gaining required energy. There are many different kinds of renewable energy sources like geothermal, biofuel, tidal and so on, but wind and solar energies are more available and accessible than other types in Middle Eastern countries. Nowadays, the rapidly increasing demand for electrical energy and the high restriction on pollution levels have led to an increasing interest in large-scale utilization of renewable energies across many countries in Middle East. This paper analyses the electricity production in Middle East and also reviews different aspects of renewable energy issues in Iran.

10/01668 The environmental and efficiency effects of restructuring on the electric power sector in the United States: an empirical analysis

Sharabaroff, A. *et al. Energy Policy*, 2009, 37, (11), 4884–4893.

Recent measures to restructure the electric power sector in different US states have raised the interest of policy makers, commentators, and the general public as to the actual impact of restructuring on both the economy and the environment. This paper focuses on two aspects of restructuring, namely its potential impact on the efficiency of electricity generation and air pollution. The empirical results suggest that restructuring contributes to improved efficiency of electricity generation and better air quality through reduced electricity-induced sulfur dioxide (SO_2) and carbon dioxide (CO_2) emissions, although no effect was found for emissions of nitrous oxides (NO_x). These results, in turn could have important implications for policy in this area.

10/01669 Towards a higher share of distributed generation in Turkey

Lise, W. *Energy Policy*, 2009, 37, (11), 4320–4328.

In 2006, there is 8.5% distributed generation (DG) in Turkey which are generation units connected to the low and medium voltage distribution network. Out of this, 56% is industrial combined heat and power production (CHP) and 20% are renewables (RES-E), mainly runoff small-scale hydro. Various technical and economical barriers have kept the DG share relatively low. This paper assesses how Turkey could increase the DG share. The methodology employed in this paper consist of a survey of the literature and legislation, combined with interviews with regulators, transmission and distribution system operators. Scenarios for DG are developed, barriers to increase the DG share are identified, DG and central generation (CG) are compared economically and regulatory measures are identified. The addition of long-run marginal transmission costs to the investment cost of new power generation units could close the long-run marginal cost difference between DG and CG. However, the share of DG is likely to stay low unless regulatory measures are taken. Moreover, a specific policy and regulation on DG is needed, the distribution grid needs strengthening, local dispatch centres need to become active and RES-E limits are needed for Turkey.

07 STEAM RAISING

Boiler operation/design

10/01670 A conceptual design of solar boiler

Muñoz, J. *et al. Solar Energy*, 2009, 83, (9), 1713–1722.

State-of-the-art concepts for solar thermal power systems are based on parabolic trough, tower or parabolic disks either heating molten salts, mineral oil, air or generating steam. In this paper, a conceptual design of a solar boiler is proposed. This concept comes from the conventional thermal power plants boiler, with the difference that the heat comes from mirrors that concentrate the solar radiation on wall-type array of solar collectors, instead of coming from fuel flames and hot gases. In the preliminary performance, analysis of this innovative solar boiler applied to electricity production, the authors have found that overall efficiency of the conversion from direct solar irradiation energy to electricity is above 20%, which is comparable to the value of parabolic trough and central tower technologies. Besides that, the concept seems very robust and could overcome some drawbacks derived from pressure losses, control complexity and material thermo-mechanical stress.

10/01671 Direct methane solid oxide fuel cell working by gradual internal steam reforming: analysis of operation

Klein, J.-M. *et al. Journal of Power Sources*, 2009, 193, (1), 331–337.

A solid oxide fuel cell was designed to be operated with pure hydrocarbons, without additive or carrier gas, in order to bring technological simplifications, cost reductions and to extend the fuel flexibility limits. The cell was built-up from a conventional cell (LSM/YSZ/Ni-YSZ), to which was added a Ir–CeO_2 catalyst layer at the anode side and an original current collecting system. The cell was first operated with steam in gradual internal reforming (GIR) conditions ($R = [H_2O]/[CH_4] < 1$) with carrier gas at the anode. The optimal operating parameters were determined in terms of flow rates, cell potential, and fuel utilization. The cell was finally operated with pure dry methane at 900 °C at 0.6 V yielding current density of about 0.1 A cm^{-2} at max power for 120 h. Small but abrupt deterioration of the performances was observed, but no carbon deposition. Electrical and chemical analysis of this degradation are provided. At total, the fuel cell was operated for more than 200 h in pure dry methane, demonstrating that gradual internal reforming actually occurred efficiently in the anode compartment, which make possible operation without reforming agent such as H_2O or CO_2 for other hydrocarbon fuels.

10/01672 Semi 2D modeling of the horizontal steam generator PGV-1000 using the RELAP5 code

Zarifi, E. *et al. Progress in Nuclear Energy*, 2009, 51, (8), 788–798.

Developing a reliable thermal-hydraulic model of the steam generator is an essential process in the steady state and transient analysis for the pressurized water reactor type of nuclear power plant. This paper provides a semi two-dimensional thermal-hydraulic model of the PGV-1000 horizontal steam generator using the RELAP5 code. Applying the qualified nodalization and the cross-flow effects are some of the advantages in the present model. The obtained results from the RELAP5 steady state analysis showed a reasonable agreement with the Bushehr NPP final safety analysis reports.

10/01673 Thermodynamic analysis of a FBCC steam power plant

Eskin, N. *et al. Energy Conversion and Management*, 2009, 50, (9), 2428–2438.

This article presents the analysis of first and second laws of thermodynamics in a 7.7 MW steam power plant located in Torbali (Izmir, Turkey). It involves a fluidized bed, a waste heat boiler (WHB) and an economizer as subsystems. Fans, pumps, cyclone and chimney are also considered through the analysis as auxiliary systems in the thermal plant. The analysis is performed for the whole system and subsystems by considering the available energy balance. In this analysis which consists of a detailed fluidized bed coal combustor (FBCC) model, the amount of irreversibilities occurring in the system is calculated at each location. Analysis results are compared with the test results obtained from the measurements at several locations in the system and good agreement is observed. These measured values are the temperatures at three levels in the FBCC and boiler, economizer exit temperatures as well as flue gas composition at the boiler exit and steam flow rate. The maximum error observed in temperature values and steam flow rate is about 3.03% and 4.03%, respectively. Through the developed and validated model, effects of excess air and ambient temperature on first and second law efficiency of the subsystems and overall system are investigated. The second-law analysis reveals that the FBCC has the largest irreversibility, with about 80.4% of the total system exergy loss. The FBCC temperature, first and second law efficiencies decrease 19.8%, 5.1% and 5.2%, respectively, as the excess air increases from 10% to 70%. Also steam flow rate decreases 5.1%. As the ambient temperature increases from 25 to 45 °C, the FBCC temperature, system first and second law efficiencies increase 0.8%, 1.3%, and 1.3%, respectively.

08 COMBUSTION

Burners, combustion systems

10/01674 A study of photon interaction in some building materials: high-volume admixture of blast furnace slag into Portland cement

Kurudirek, M. *et al. Radiation Physics and Chemistry*, 2009, 78, (9), 751–759.

Total mass attenuation coefficients, mean free paths (MFP), half-value (HVT) and tenth-value (TVT) thicknesses of Portland cement and three mixtures have been calculated in function of the energy from 1 keV to 100 GeV. Both in the low- and high-energy region there were significant variations in those parameters where photoelectric process and pair production partially dominates, respectively. In general, the attenuation parameters were found to vary with chemical composition, density of given material and photon energy.

10/01675 An evaluation on rice husks and pulverized coal blends using a drop tube furnace and a thermogravimetric analyzer for application to a blast furnace

Chen, W.-H. and Wu, J.-S. *Energy*, 2009, 34, (10), 1458–1466.

To evaluate the potential of pulverized coals partially replaced by rice husks used in blast furnaces, thermal behaviour of blends of rice husks and an anthracite coal before and after passing through a drop tube furnace (DTF) was investigated by using a thermogravimetry (TG). For the blends of the raw materials in the TG, fuel reaction with increasing temperature could be partitioned into three stages. When the rice husks were contained in the fuel, a double-peak distribution in the first stage was observed, as a consequence of thermal decompositions of hemicellulose, cellulose and lignin. A linear relationship between the char yield and the biomass blending ratio (BBR) developed, reflecting that synergistic effects in the pyrolytic processes were absent. This further reveals that the coal and the rice husks can be blended and consumed in blast furnaces in accordance with the requirement of volatile matter contained in the fuel. After the fuels underwent rapid heating (i.e. the DTF), a linear relationship from the thermogravimetric analyses of the unburned chars was not found. Therefore, the synergistic effects were observed and they could be described by second order polynomials. When the BBR was less than 50%, varying the ratio had a slight effect on the thermal behaviour of the unburned chars. In addition, the thermal reactions of the feeding fuels and of the formed unburned chars behaved like a fingerprint.

10/01676 Confined pyrolysis of Tertiary lacustrine source rocks in the Western Qaidam Basin, Northwest China: implications for generative potential and oil maturity evaluation

Pan, C. *et al. Applied Geochemistry*, 2010, 25, (2), 276–287.

The parameter $S_1 + S_2$ (genetic potential) of Rock-Eval analysis is widely used as an evaluation of the genetic potential for the source rocks. Oligocene–Miocene saline lacustrine source rocks in the western Qaidam basin have low total organic C contents (TOC), most around 0.5% with a few exceptions 1.0%. Mineral matrix effects are substantial for source rocks with low TOC, resulting in relatively low S_1 and S_2 peaks. Based on the results of confined pyrolyses (sealed Au capsules) on six Oligocene–Miocene source rocks from the western Qaidam basin, with TOC ranging between 0.48% and 2.22%, the relationship between the $S_1 + S_2$ parameter and the maximum amount of extracted bitumen or saturated and aromatic hydrocarbons (SA) after the confined pyrolysis has been established as follows: bitumen (mg/g rock) = $1.4924 \times (S_1 + S_2) + 0.3201$ ($r = 0.987$), or SA (saturates + aromatics) (mg/g rock) = $0.7083 \times (S_1 + S_2) + 0.4045$ ($r = 0.992$). Based on these formulas, the amounts of hydrocarbons generated from source rocks can be reasonably estimated. The typical crude oils with low biomarker maturities in this region appear substantially different to the pyrolysates of these six rocks at 180–300 °C but comparable to the pyrolysates at 320 °C and higher temperatures based on molecular parameters. This result, in combination with the physical and gross compositions of the crude oils, suggests that the majority of these crude oils were generated from the source rocks during the main oil-generative stage, possibly at a maturity higher than R_o 0.74%.

10/01677 Effect of biomass on burnouts of Turkish lignites during co-firing

Haykiri-Acma, H. and Yaman, S. *Energy Conversion and Management*, 2009, 50, (9), 2422–2427.

Co-firing of some low-quality Turkish lignites with woody shells of sunflower seed was investigated via non-isothermal thermogravimetric analysis method. For this purpose, Yozgat-Sorgun, Erzurum-Askale, Tuncbilek, Gediz, and Afsin-Elbistan lignites were selected, and burnouts of these lignites were compared with those of their blends. Biomass was blended as much as 10 and 20 wt.% of the lignites, and heating was performed up to 900 °C at a heating rate of 40 °C/min under dry air flow of 40 mL/min. This study revealed that the same biomass species may have different influences on the burnout yields of the lignites. Burnouts of Erzurum-Askale lignite increased at any temperature with the increasing ratio of biomass in the blend, whereas burnout yields of other lignites decreased to some extent. Nevertheless, the blends of Turkish lignites with sunflower seed shell did not behave in very different way, and it can be concluded that they are compatible in terms of burnouts for co-combustion in a combustion system. Although the presence of biomass in the lignite blends caused to some decreases in the final burnouts, the carbon dioxide neutral nature of biomass should be taken into account, and co-combustion is preferable for waste-to-energy-management.

10/01678 Effects of premixed flames on turbulence and turbulent scalar transport

Lipatnikov, A. N. and Chomiak, J. *Progress in Energy and Combustion Science*, 2010, 36, (1), 1–102.

Experimental data and results of direct numerical simulations are reviewed in order to show that premixed combustion can change the basic characteristics of a fluctuating velocity field (the so-called flame-generated turbulence) and the direction of scalar fluxes (the so-called countergradient or pressure-driven transport) in a turbulent flow. Various approaches to modelling these phenomena are discussed and the lack of a well-elaborated and widely validated predictive approach is emphasized. Relevant basic issues (the transition from gradient to countergradient scalar transport, the role played by flame-generated turbulence in the combustion rate, the characterization of turbulence in premixed flames, etc.) are critically considered and certain widely accepted concepts are disputed. Despite the substantial progress made in understanding the discussed effects over the past decades, these basic issues strongly need further research.

10/01679 Estimation for inner surface geometry of furnace wall using inverse process combined with grey prediction model

Su, C.-R. *et al. International Journal of Heat and Mass Transfer*, 2009, 52, (15–16), 3595–3605.

In this work the inner surface geometry of a cylindrical furnace wall is estimated using inverse process method combined with grey prediction model. In estimating process a virtual area extended from the inner surface of furnace wall is used for analysis. The heat conduction equation and the boundary condition are first discretized by finite difference method to form a linear matrix equation; the inverse model is then optimized by linear least-squares error method and the temperatures of virtual boundary are obtained from a few of measured temperatures in furnace wall using the linear inverse model; and finally the temperature distribution of system is got by direct process and the inner surface geometry of furnace wall can be estimated accordingly. The result shows that using inverse process combined with grey prediction model the geometry can be exactly estimated from relatively small number of measured temperatures. Moreover, the effects of measurement error, location, and number of measured points on the estimation for inner surface geometry of furnace wall are discussed in detail.

10/01680 Experimental analysis of the ignition front propagation of several biomass fuels in a fixed-bed combustor

Porteiro, J. *et al. Fuel*, 2010, 89, (1), 26–35.

Fixed-bed combustion in a tube reactor is a useful procedure to exploit a large variety of biomasses obtaining accurate in-bed data. In this paper, the ignition front propagation velocity is experimentally studied in a counter-current process for eight different biomass fuels with a wide range of origins, compositions and packing properties. Air mass flow rate is the main operative parameter and clearly distinguishes three stages of combustion (oxygen-limited, fuel limited and cooling by convection). The impact of the excess air ratio is also analysed. This parameter confirmed that the maximum front velocity is achieved under sub-stoichiometric conditions, where the cooling effects of excessive air are minimized. Other variables with a major influence on the ignition front velocity are moisture and ash content. Finally, an uncertainty analysis is included to determine the accuracy of the entire measurement process.

10/01681 Extinction of laminar partially premixed flames

Aggarwal, S. K. *Progress in Energy and Combustion Science*, 2009, 35, (6), 528–570.

Flame extinction represents one of the classical phenomena in combustion science. It is important to a variety of combustion systems in transportation and power generation applications. Flame extinguishment studies are also motivated from the consideration of fire safety and suppression. Such studies have generally considered non-premixed and premixed flames, although fires can often originate in a partially premixed mode, i.e. fuel and oxidizer are partially premixed as they are transported to the reaction zone. Several recent investigations have considered this scenario and focused on the extinction of partially premixed flames (PPFs). Such flames have been described as hybrid flames possessing characteristics of both premixed and non-premixed flames. This paper provides a review of studies dealing with the extinction of PPFs, which represent a broad family of flames, including double, triple (tribrachial), and edge flames. Theoretical, numerical and experimental studies dealing with the extinction of such flames in coflow and counterflow configurations are discussed. Since these flames contain both premixed and non-premixed burning zones, a brief review of the dilution-induced extinction of premixed and non-premixed flames is also provided. For the coflow configuration, processes associated with flame liftoff and blowout are described. Since lifted non-premixed jet flames often contain a partially premixed or an edge-flame structure prior to blowout, the review also considers such flames. While the perspective of this review is broad focusing on the fundamental aspects of flame extinction and blowout, results mostly consider flame extinction caused by the addition of a flame suppressant, with relevance to fire suppression on earth and in space environment. With respect to the latter, the effect of gravity on the extinction of PPFs is discussed. Future research needs are identified.

10/01682 Lean flammability limits for stable performance with a porous burner

Akbari, M. H. *et al. Applied Energy*, 2009, 86, (12), 2635–2643.

Applications of porous burners are of high interest due to many advantages such as extended lean flammability limit in comparison with free flame structures. This study investigates numerically laminar premixed flame propagation of methane/air mixture in a porous medium. An unsteady one-dimensional physical model of a porous burner is considered, in which the flame location is not predetermined. The computational domain is extended beyond either side of the porous medium to accurately model reactions close to the edges of the solid matrix. After validation of the model and performing a baseline simulation, a parametric study is carried out to investigate the lean flammability limits of the burner and the unstable flash-back/blow-out phenomena. Stable performance diagrams are given for two controlling parameters of turn–down ratio and porous medium porosity. The simulation results indicate that the stable performance range of the burner is extended when the equivalence ratio increases; however, the blow-out region expands with an increase in the firing rate. For constant values of porosity and firing rate, increasing the equivalence ratio can change the operating regime of the burner from blow-out to a stable condition. It is observed that by the variation of porosity in the range of 0.6–0.9, and for the equivalence ratios of more than 0.6, the flame flash-back cannot occur. An equivalence ratio of 0.43 is found to be the lower limit at which the flame stabilizes in the matrix.

10/01683 Modelling methods for co-fired pulverised fuel furnaces

Ma, L. *et al. Fuel*, 2009, 88, (12), 2448–2454.

Co-firing of biomass and coal can be beneficial in reducing the carbon footprint of energy production. Accurate modelling of co-fired furnaces is essential to discover potential problems that may occur during biomass firing and to mitigate potential negative effects of biomass fuels, including lower efficiency due to lower burnout and NO$_x$ formation issues. Existing coal combustion models should be modified to increase reliability of predictions for biomass, including factors such as increased drag due to non-spherical particle sizes and accounting for organic compounds and the effects they have on NO$_x$ emission. Detailed biomass co-firing models have been developed and tested for a range of biomass fuels and show promising results.

10/01684 Modelling of instabilities in turbulent swirling flames

Ranga Dinesh, K. K. J. *et al. Fuel*, 2010, 89, (1), 10–18.

A large eddy simulation-based data analysis procedure is used to explore the instabilities in turbulent non-premixed swirling flames. The selected flames known as SM flames are based on the Sydney swirl burner experimental database. The governing equations for continuity, momentum and mixture fraction are solved on a structured Cartesian grid and the Smagorinsky eddy viscosity model with dynamic procedure is used as the sub-grid scale turbulence model. The thermo-chemical variables are described using the steady laminar flamelet model. The results show that the LES successfully predicts the upstream first recirculation zone generated by the bluff body and the downstream second recirculation zone induced by swirl. Overall, LES comparisons with measurements are in good agreement. Generated power spectra and snapshots demonstrate oscillations of the centre jet and the recirculation zone. Snapshots of flame SM1 showed irregular precession of the centre jet and the power spectrum at a downstream axial location situated between the two recirculation zones showed distinct precession frequency. Mode II instability defined as cyclic expansion and collapse of the recirculation zone is also identified for the flame SM2. The coupling of swirl, chemical reactions and heat release exhibits Mode II instability. The presented simulations demonstrate the efficiency and applicability of the LES technique to swirl flames.

10/01685 OXYCOAL-AC: towards an integrated coal-fired power plant process with ion transport membrane-based oxygen supply

Kneer, R. *et al. Energy & Environmental Science*, 2010, 3, (2), 198–207.

The cooperative project OXYCOAL-AC aims to develop a zero-CO$_2$-emission coal combustion process for power generation. This article focuses on membrane-based air separation modules and their design for oxycoal conditions, the specifics of coal combustion in a CO$_2$/O$_2$ atmosphere including related burner design as well as the cleaning of hot flue gas from oxycoal combustion. OXYCOAL-AC is the first test plant where coal can be burnt in a stable flame in a CO$_2$ atmosphere with an oxygen content as low as 18% up to above 30%. The development of ion-transport membranes is an on-going issue and design concepts of scaled-up membrane modules and their integration in pilot- and power-plant-scale facilities are under development.

10/01686 Simultaneous measurements of two-dimensional temperature and particle concentration distribution from the image of the pulverized-coal flame

Wang, F. *et al. Fuel*, 2010, 89, (1), 202–211.

This paper presented a model for simultaneously measuring the two-dimensional temperature and particle concentration distribution from the images of the flame. In order to determine the relationship between a point in the three-dimensional space and its image in the camera, the optical image-formation process was analysed. The inverse problem of the radiation transfer in the participating medium was studied. The mathematics method to simultaneously solve the temperature and the particle concentration was discussed. To validate the model presented in this paper, a test furnace with the fuels mixed by pulverized-coal and oil was set up. The temperature and particle concentration of a cross-section were measured under different coal feed rates. The comparison between the measured temperature by the pyrometer and the calculated temperature according to the flame image proved that the two-dimensional distribution of temperature can be obtained accurately. The particle concentration distribution was reasonable under different cases.

10/01687 Study of the slow batch pyrolysis of mixtures of plastics, tyres and forestry biomass wastes

Paradela, F. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 85, (1–2), 392–398.

This work aimed to study the recovery of three types of waste by the process of pyrolysis: biomass, plastics and used tyres. The effects of experimental conditions in products yield and composition were studied. The increase of reaction time increased alkane content both in gas phase from 53% to 70% v/v and in liquid fraction from 48% to 60% w/w. The rise of reaction temperature led to a decrease of liquid yield (from 82% to 73% w/w), which was followed by the increase of solids and gases. The increase of reaction temperature also allowed the increase of the alkane content in gas phase from 39% to 70% v/v. The parameter that most affected products yield and composition was plastics content on the wastes initial mixture. The enhancement of this parameter increased liquid yield from 33% to 92% w/w, at the expense of solids and gases contents and also decreased aromatic contents from 52% to 28% w/w.

10/01688 Testing the performance and compatibility of degummed soybean heating oil blends for use in residential furnaces

Jiru, T. E. *et al. Fuel*, 2010, 89, (1), 105–113.

Degummed soybean heating oil (SHO) is a renewable energy resource, which can reduce dependence on foreign oil and create a new market for the soybean industry. This study demonstrated that SHO 20 (20% degummed soybean oil and 80% No. 2 fuel oil) is suitable for application in residential furnaces without modification. The tests conducted were: fuel properties, seal compatibility, long-term storage, and laboratory and field combustion. The physical property tests showed that the kinematic viscosity ($0.0346\,\mathrm{cm^2/s}$) and the pour point of SHO 20 (−30 °C) were within the ASTM requirement for No. 2 fuel oil; and the net heating value of SHO 20 (43.9 MJ/kg) was only 1–3% lower than the No. 2 fuel oil value (45.6 MJ/kg). Compatibility tests performed on the rubber seals and gasket materials (Nitrile and Viton) found in typical heating fuel pump systems indicated that the tensile strength and hardness values were not significantly affected by SHO blends when compared with No. 2 fuel oil. A long-term storage test revealed that there was no significant change in heat content and no visible stratification of SHO 20 blend during three months of storage. The pump pressure and the type of nozzle used affected the concentration of NO$_x$, SO$_2$, and CO in the flue gas. As was expected, increasing the SHO fraction in the blend also reduced the SO$_2$ emission. The combustion of SHO 20 resulted in a higher flue gas temperature which increased the NO$_x$ emission than with No. 2 fuel oil.

Fire safety

10/01689 A combustion chemistry analysis of carbonate solvents used in Li-ion batteries

Harris, S. J. *et al. Journal of Power Sources*, 2009, 193, (2), 855–858.

Under abusive conditions Li-ion cells can rupture, ejecting electrolyte and other flammable gases. This study considers some of the thermochemical and combustion properties of these gases that determine whether they ignite and how energetically they burn. A significant variation was found among the carbonate solvents in the factors that are important to determining flammability, such as combustion enthalpy and vaporization enthalpy. The authors also show that flames of carbonate solvents are fundamentally less energetic than those of conventional hydrocarbons. An example of this contrast is given using a recently developed mechanism for dimethyl carbonate (DMC) combustion, where it was shown that a diffusion flame burning DMC has only half the peak heat release rate of an analogous propane flame. Interestingly, peak temperatures differ by only 25%. The authors argue that heat release rate is a more useful parameter than temperature when evaluating the likelihood that a flame in one cell will ignite a neighbouring cell. The results suggest that thermochemical and combustion property factors might well be considered when choosing solvent mixtures when flammability is a concern.

10/01690 Calculation of fault current-division factors and assessment of earth-grid safety at an independent power producer station

Lee, C.-H. *et al. International Journal of Electrical Power & Energy Systems*, 2009, 31, (10), 639–650.

This paper calculates fault current-division factors and assesses earth-grid safety at 17.1/161-kV Chiahui independent power producer (IPP). A method based on the grid current is proposed to calculate fault current-division factors and the results are compared with the Endrenyi method as well as the current-distribution electromagnetic-grounding and soil-structure analysis (CDEGS) program. Since the coupling effect of overhead earth wires to phase conductors was not taken into account by the Endrenyi method, the computed fault current-division factor will be greater than those obtained by the proposed method and CDEGS program. Moreover, mesh and step voltages are computed to compare with minimum touch and step voltages for assessing earth-grid safety, respectively. As a result, the design of earthing systems at 17.1/161-kV IPP station is safe for humans with 50 kg and 70 kg body weight.

10/01691 Coal dust/air explosions in a large-scale tube

Liu, Q. *et al. Fuel*, 2010, 89, (2), 329–335.

Coal dust/air mixture explosions under weak ignition conditions have been studied in a horizontal experimental tube of diameter 199 mm and length 29.6 m. The experimental tube is closed at one end and open at the downstream end. An array of 40 equally spaced dust dispersion units was used to disperse coal dust particles into the experimental tube. The coal dust/air mixture was ignited by an electric spark. A constant-temperature hot-wire anemometer was used to measure the gas velocity during the dispersion process. Kistler piezoelectric pressure sensors were used to measure the propagation of the pressure wave during the explosion process. The maximum overpressure of the coal dust explosion under the weak ignition conditions in the tube was 70 kPa and the propagation velocity of the pressure wave along the tube was approximately 370 m/s. The minimum concentration for obtaining a coal dust explosion that propagated along the tube was 120 g/m^3. The suppressing effects on the coal dust explosion of two different kinds of suppressing agents have been studied.

10/01692 Risk-informed process and tools for permitting hydrogen fueling stations

LaChance, J. *et al. International Journal of Hydrogen Energy*, 2009, 34, (14), 5855–5861.

The permitting process for hydrogen-fuelling stations requires demonstration that the proposed facility meets certain safety requirements. Currently, many permitting authorities rely on compliance with well-known codes and standards as evidence of a safe design. To ensure that a hydrogen facility is indeed safe, the code and standard requirements should be identified using a risk-informed process that utilizes an acceptable level of risk. This paper describes an approach for risk-informing the permitting process for hydrogen-fuelling stations that relies primarily on the establishment of risk-informed codes and standards. Using accepted quantitative risk assessment (QRA) techniques and the established risk criteria, the minimum code and standard requirements necessary to ensure the safe operation of hydrogen facilities can be identified. To facilitate consistent risk-informed approaches, the participants in the International Energy Agency (IEA) Task 19 on hydrogen safety are working to identify acceptable risk criteria, QRA models, and supporting data.

09 PROCESS HEATING, POWER AND INCINERATION

Energy applications in industry

10/01693 A fuzzy decision tree method for fault classification in the steam generator of a pressurized water reactor

Zio, E. *et al. Annals of Nuclear Energy*, 2009, 36, (8), 1159–1169.

This paper extends a method previously introduced by the authors for building a transparent fault classification algorithm by combining the fuzzy clustering, fuzzy logic and decision trees techniques. The baseline method transforms an opaque, fuzzy clustering-based classification model into a fuzzy logic inference model based on linguistic rules which can be represented by a decision tree formalism. The classification model thereby obtained is transparent in that it allows direct interpretation and inspection of the model. An extension in the procedure for the development of the fuzzy logic inference model is introduced to allow the treatment of more complicated cases, e.g. splitted and overlapping clusters. The corresponding computational tool developed relies on a number of parameters, which can be tuned by the user to optimally compromise the level of transparency of the classification process and its efficiency. A numerical application is presented with regards to the fault classification in the steam generator of a pressurized water reactor.

10/01694 An integrated approach to energy and chemicals production

Metcalfe, I. S. *et al. Energy & Environmental Science*, 2010, 3, (2), 212–215.

This paper describes an integrated process that generates energy by the combustion of methane in a pure oxygen atmosphere. It then produces commercially important cyclic carbonates from the waste carbon dioxide generated during the combustion process.

10/01695 Applying heat integration total site based pinch technology to a large industrial area in Japan to further improve performance of highly efficient process plants

Matsuda, K. *et al. Energy*, 2009, 34, (10), 1687–1692.

'Area-wide pinch technology' which consists of R-curve analysis and site source sink profile analysis, was applied to the Kashima industrial area, one of the biggest heavy chemical complexes in Japan. This case study demonstrates that despite the very high efficiency of the individual sites in the complex, there is a huge amount of energy-saving potential through energy sharing among the various sites. In addition it was found that appropriate use of the available pinch technology tools and techniques allows an industrial area of enormous scale and complexity to be analysed conveniently. This has resulted in a number of practical area-wide energy-saving projects being proposed and implemented.

10/01696 Design and simulation of a small polygeneration plant cofiring biomass and natural gas in a dual combustion micro gas turbine (BIO_MGT)

Riccio, G. and Chiaramonti, D. *Biomass and Bioenergy*, 2009, 33, (11), 1520–1531.

The operation and performances of an innovative small-scale poly-generation system (BIO_MGT), which combines biomass and natural gas in a micro gas turbine, has been simulated in the present work by means of a thermodynamic matching analysis. The BIO_MGT unit matches an externally fired cycle with a commercial micro gas turbine (MGT, 100 kWe). A significant share of the total energy input (70%) is supplied by solid biomass: the remaining is provided by natural gas. The system is therefore characterized by a dual combustion system. The configuration of the plant has been conceived so to require only minor modifications to conventional MGTs and biomass furnaces available on the market. This paper describes the design of the proposed bioenergy plant as well as the structure and the application of the in-house developed simulation model AMOS which has been used as computer-aid design tool. The design activity compared various plant schemes available from literature or past research works. The thermodynamic matching analysis of the selected configuration was then carried out, with the aim to verify compressor and turbine working points and to compare these with those typical of the MGT working under standard natural gas conditions. The steady-state matching analysis was based on the performance maps (i.e. characteristic lines) of each component. The design specifications and operating range for main and sub-components were defined, and the BIO_MGT performance maps were computed. The results showed that both the turbine as well as the compressor will work within the acceptable limits, and plant performances have also been calculated at part load conditions.

10/01697 Energetic and exergetic assessment of a trass mill process in a cement plant

Sogut, M. Z. *et al. Energy Conversion and Management*, 2009, 50, (9), 2316–2323.

Cement production has become one of the most intensive energy industries in the world. The main objective of this study is to assess the performance of a trass mill in a cement plant based on the actual operational data using energy and exergy analysis method. In the process, the overall exergy efficiencies are found to be less than the corresponding energy efficiencies; e.g. 74% and 10.68% for energy and exergy efficiency, respectively. Using energy recovery systems, waste heat energy may be captured, while energy and exergy efficiency values can be improved to 84% and 48%, respectively. It may also be concluded that the analyses reported here will provide the investigators with knowledge about how effectively and efficiently a sector uses its energy resources.

10/01698 Energy efficiency and the influence of gas burners to the energy related carbon dioxide emissions of electric arc furnaces in steel industry

Kirschen, M. *et al. Energy*, 2009, 34, (9), 1065–1072.

Determining the complete energy balance of an electric arc furnace (EAF) provides an appropriate method to examine energy efficiency and identify energy saving potentials. However, the EAF energy balance is complex due to the combined input of electrical energy and chemical energy resulting from natural gas (NG) combustion and oxidation reactions in the steel melt. In addition, furnace off-gas measurements and slag analysis are necessary to reliably determine energy sinks. In this paper 70 energy balances and energy efficiencies from multiple EAFs are presented, including data calculated from plant measurements and compiled from the literature. Potential errors that can be incorporated in these calculations are also highlighted. The total energy requirement of these modern EAFs analysed ranged from 510 to 880 kWh/t, with energy efficiency values $(\eta = \Delta H_{\mathrm{Steel}}/E_{\mathrm{Total}})$ of between 40% and 75%. Furthermore, the focus was placed on the total energy related CO_2 emissions of EAF processes comprising NG combustion and electrical energy input. By assessing multiple EAF energy balances, a significant correlation between the total energy requirement and energy related specific CO_2 emissions was not evident. Whilst the specific consumption of NG in the EAF only had a minor impact on the EAF energy efficiency, it decreased the specific electrical energy requirement and increased EAF productivity where transformer power was restricted. The analysis also demonstrated that complementing and substituting electrical energy with NG was beneficial in reducing the total energy related CO_2 emissions when a certain level of substitution efficiency was achieved. Therefore, the appropriate use of NG burners in modern EAFs can result in an increased EAF energy intensity, whilst the total energy related CO_2 emissions remain constant or are even decreased.

10/01699 Experimental studies on a novel swirling fluidized-bed combustor using an annular spiral air distributor

Kaewklum, R. and Kuprianov, V. I. *Fuel*, 2010, 89, (1), 43–52.

This work reports studies on hydrodynamics as well as combustion and emission characteristics of a conical swirling fluidized-bed combustor (SFBC) using an annular spiral air distributor as the swirl generator. In the experimental study on a 'cold' SFBC model, hydrodynamic regimes and characteristics of an air–sand bed were investigated for variable bed particle size and static bed height. Depending on the superficial air velocity, the bed exhibited four operational regimes. Based on the results from the 'cold' hydrodynamic study, optimum bed characteristics (sand particle size and bed height) and the range of primary air were determined prior to the combustion tests. In the second part of this work, a conical SFBC was tested for firing 80 kg/h rice husk. During the combustion tests, swirl motion of a fluidized bed was induced by primary air injected into the bed through the air distributor and, also, sustained by tangential injection of secondary air into the bed splash zone. Radial and axial temperature and gas (O_2, CO, NO) concentration profiles in the reactor were obtained for 20–80% excess air. Effects of operating conditions on formation and decomposition of major gaseous pollutants (CO and NO) in the reactor are discussed. Both CO and NO were found to be reduced significantly in the bed splash zone, resulting in quite low CO and moderate NO emissions from the reactor. High combustion efficiency, 99.4–99.5%, is achievable when burning rice husk in the proposed conical SFBC at 80 kg/h feed rate and excess air of 40–80%.

10/01700 Feasibility study into the potential for gasification plant in the New Zealand wood processing industry

Penniall, C. L. and Williamson, C. J. *Energy Policy*, 2009, 37, (9), 3377–3386.

The purpose of this paper is to investigate the feasibility of installing gasification-based energy plants in the New Zealand wood processing industry. The study compared energy plants supplying the thermal and electrical energy in sawmills, laminated veneer lumber (LVL) plants and medium density fibreboard (MDF) mills. The breakeven electricity price for the MDF and LVL scenarios ranged from 4–8.9 c/kWh while the sawmill scenario was 11.6 c/kWh. The conclusion of the study is that while the economics are comparable with other renewable energy generation methods such as hydro and wind the location of the plant is critical to overall feasibility due mainly to biomass availability and power price both now and in light of expected future trends. The technology is complementary to the government's forward strategy which encourages both distributed generation and renewable energy.

10/01701 Micro-crack growth behavior and life in high temperature low cycle fatigue of blade root and disc joint for turbines

Isobe, N. and Nogami, S. *International Journal of Pressure Vessels and Piping*, 2009, 86, (9), 622–627.

Low cycle fatigue tests were carried out at a temperature of 600 °C using a component specimen of 12%-Cr steel, which simulates a blade root and disc joint for turbines. The growth behaviour of micro-cracks in the joint region of the specimens was investigated to clarify the damage mechanism of blade-root joints used in high temperature environments and to improve life assessment methods using finite element analysis. Micro-crack growth behaviour similar to that in smooth bar specimens was observed in the specimens tested under conditions of relatively high total strain. Micro-cracks initiation was observed at the notch region of the specimens at an early stage. The crack growth rate increased with surface crack length. The fatigue life of the component specimens under this condition was similar to that of smooth bar specimens. Meanwhile, the component specimens tested under conditions of relatively low total strain showed a different growth behaviour. No cracks were observed at the notch region and some micro-cracks were initiated at the edge of the contact region of the specimens in the early stages. Almost no increase in the crack growth rate was observed. Life of the component specimens under this condition was shorter than that of the smooth bar specimens. This might be attributed to fretting fatigue at the contact edge and to mean stresses.

10/01702 Regional electric power demand elasticities of Japan's industrial and commercial sectors

Hosoe, N. and Akiyama, S.-I. *Energy Policy*, 2009, 37, (11), 4313–4319.

In the assessment and review of regulatory reforms in the electric power market, price elasticity is one of the most important parameters that characterize the market. However, price elasticity has seldom been estimated in Japan; instead, it has been assumed to be as small as 0.1 or 0 without proper examination of the empirical validity of such *a priori* assumptions. The authors estimated the regional power demand functions for nine regions, in order to quantify the elasticity, and found the short-run price elasticity to be 0.09–0.30 and the long-run price elasticity to be 0.12–0.56. Inter-regional comparison of the estimation results suggests that price elasticity in rural regions is larger than that in urban regions. Popular assumptions of small elasticity of 0.1, for example, could be suitable for examining Japan's aggregate power demand but not power demand functions that focus on respective regions. Furthermore, assumptions about smaller elasticity values such as 0.01 and 0 could not be supported statistically by this study.

10 SPACE HEATING AND COOLING/HEAT PUMPS

10/01703 A comparison of heat transfer enhancement in a medium temperature thermal energy storage heat exchanger using fins

Agyenim, F. *et al. Solar Energy*, 2009, 83, (9), 1509–1520.

An experimental energy storage system has been designed using a horizontal concentric tube heat exchanger incorporating a medium temperature phase change material (PCM) Erythritol, with a melting point of 117.7 °C. Three experimental configurations, a control system with no heat transfer enhancement and systems augmented with circular and longitudinal fins have been studied. The results presented compare the system heat transfer characteristics using isotherm plots and temperature–time curves. The system with longitudinal fins gave the best performance with increased thermal response during charging and reduced subcooling in the melt during discharging. The experimentally measured data for the control, circular finned and longitudinal finned systems have been shown to vindicate the assumption of axissymmetry (direction parallel to the heat transfer fluid flow) using temperature gradients in the axial, radial and angular directions in the double pipe PCM system.

10/01704 A robust model predictive control strategy for improving the control performance of air-conditioning systems

Huang, G. *et al. Energy Conversion and Management*, 2009, 50, (10), 2650–2658.

This paper presents a robust model predictive control strategy for improving the supply air temperature control of air-handling units by dealing with the associated uncertainties and constraints directly. This strategy uses a first-order plus time-delay model with uncertain time-delay and system gain to describe air-conditioning process of an air-handling unit usually operating at various weather conditions. The uncertainties of the time-delay and system gain, which imply the non-linearities and the variable dynamic characteristics, are formulated using an uncertainty polytope. Based on this uncertainty formulation, an offline LMI-based robust model predictive control algorithm is employed to design a robust controller for air-handling units which can guarantee a good robustness subject to uncertainties and constraints. The proposed robust strategy is evaluated in a dynamic simulation environment of a variable air volume air-conditioning system in various operation conditions by comparing with a conventional PI control strategy. The robustness analysis of both strategies under different weather conditions is also presented.

10/01705 A study on the effects of double skin façades on the energy management in buildings

Chou, S. K. *et al. Energy Conversion and Management*, 2009, 50, (9), 2275–2281.

Double skin façades (DSF) are gaining popularity for their ability to reduce solar heat gain in buildings. However, research works on the impact of DSF on the energy management, aerophysics and air conditioning of buildings are still in their infancy. The concept of envelope thermal transfer value (ETTV) has been specifically applied to evaluate the solar radiation gain component through a DSF fenestration system. The aim of this paper is to study the effects of DSF on the solar heat gain, the ETTV and hence the energy management within buildings. A systematic methodology to investigate the effectiveness of DSF in reducing solar heat gain has been presented. Experimental works have been performed to obtain the solar heat gain coefficient (SHGC) values of a DSF fenestration system. These values are then applied to compare the ETTVs generated from a model building with different DSF configurations, namely, different wall-to-window ratios and varying shading coefficients.

10/01706 Advanced exergetic evaluation of refrigeration machines using different working fluids

Morosuk, T. and Tsatsaronis, G. *Energy*, 2009, 34, (12), 2248–2258.

Splitting the exergy destruction into endogenous/exogenous and unavoidable/avoidable parts has many advantages for the detailed analysis of energy conversion systems. Endogenous is the exergy destruction obtained when all other system components are ideal and the component being considered operates with its real efficiency. The difference between total and endogenous exergy destruction is the exogenous exergy destruction caused within the component being considered by the irreversibilities in the remaining components and the structure of the overall system. Unavoidable is the part of exergy destruction within one system component that cannot be eliminated even if the best available technology in the near future would be applied. The avoidable exergy destruction is the difference between total and unavoidable exergy destruction. These concepts enhance an exergy analysis and assist in improving the quality of the conclusions obtained from this analysis. This study presents the combined application of both concepts to vapour-compression refrigeration machines using different one-component working fluids (R125, R134a, R22 and R717) as well as azeotropic (R500) and zeotropic (R407C) mixtures. The purpose of the paper is not to evaluate these working fluids, some of which cannot be used in future, but to demonstrate the effect of different material properties on the results of advanced exergy analysis.

10/01707 An exergy application for analysis of buildings and HVAC systems

Sakulpipatsin, P. *et al. Energy and Buildings*, 2010, 42, (1), 90–99.

The paper presents an extended method for exergy analysis of buildings and heating, ventilation and air-conditioning (HVAC) systems, according to an energy demand build-up model from the building side to the energy supply side. The HVAC systems comprise a thermal energy emission and control system, a thermal distribution system, an electricity distribution system and an energy conversion system. Energy and exergy that are required by a building and a HVAC system are posed into the external part and classified by different forms of energy carriers. The external part is out of the boundary of the study. The method is illustrated with an office building equipped with low-temperature heating and high-temperature cooling systems situated in the Netherlands. Thermal exergy and thermal energy demands of the building and thermal energy and thermal exergy losses occurring in the HVAC systems are discussed. The building and the HVAC systems to be considered meet standard Dutch energy performance regulations. Nevertheless their overall exergy efficiencies are low in both cases (17.15% and 6.81% subsequently). The exergy analysis also pinpoints that the thermal energy emission and control system and the energy conversion system are the main causes of the exergy inefficiencies in the heating and cooling cases, respectively.

10/01708 An hourly modelling framework for the assessment of energy sources exploitation and energy converters selection and sizing in buildings

Fabrizio, E. *et al. Energy and Buildings*, 2009, 41, (10), 1037–1050.

Multi-energy systems in buildings use more than one energy source in various energy converters to overcome the limitations that may be characteristic of each source. However, the design of the optimization of such systems is a complex task because the number of design variables is high and the boundary conditions (climate, operation strategies, etc.) are highly variable, so the system simulation has to be performed in the time domain. In this work an original hourly model, developed to optimize multi-energy systems, is presented and applied on a case study. It is an evaluation method to assess, in an integrated fashion, the performance of a building system as a whole and the viability of the exploitation of various energy sources. This tool is intended to take into account the variation of the conversion efficiency as a function of the design power, part load, boundary and climatic conditions. The relations that can model the energy converters of the case study (standard boiler, condensing boiler, various types of chillers and others) from the energy performance and from the financial points of view are also presented. This model represents a valuable alternative to currently available tools for hybrid systems simulation because of the optimization approach and of the detail in the thermal energy converters performance. Ultimately, the theoretical and applied knowledge of this contribution aims also at promoting a more conscious use of renewable and non-renewable energy in the built environment.

10/01709 An improved thermal response test for U-tube ground heat exchanger based on optical fiber thermometers

Fujii, H. *et al. Geothermics*, 2009, 38, (4), 399–406.

As part of a new thermal response test (TRT) and to determine ground thermal conductivities, vertical temperature profiles were obtained using retrievable optical fiber sensors inserted into the U-tubes of two ground heat exchangers (GHEs) installed at Maebaru City (Fukuoka, Kyushu) and Kushiro City (Hokkaido), Japan. Measured profiles and outlet temperatures from TRTs were history-matched with the cylindrical source function. Nonlinear regression was used to estimate the vertical distribution of ground thermal conductivities. The computed distribution is consistent with measured data indicating both the reliability of the optical fiber thermometer and TRT interpretation. It is expected that TRTs and optical fiber thermometers will prove to be increasingly useful for optimizing the depth of the GHEs installed in heterogeneous formations, and consequently will minimize installation costs of geothermal heat pump systems.

10/01710 Application of nanofluids in heating buildings and reducing pollution

Kulkarni, D. P. *et al. Applied Energy*, 2009, 86, (12), 2566–2573.

This paper presents nanofluid convective heat transfer and viscosity measurements, and evaluates how they perform heating buildings in cold regions. Nanofluids contain suspended metallic nanoparticles, which increases the thermal conductivity of the base fluid by a substantial amount. The heat transfer coefficient of nanofluids increases with volume concentration. To determine how nanofluid heat transfer characteristics enhance as volume concentration is increased; experiments were performed on copper oxide, aluminium oxide and silicon dioxide nanofluids, each in an ethylene glycol and water mixture. Calculations were performed for conventional finned-tube heat exchangers used in buildings in cold regions. The analysis shows that using nanofluids in heat exchangers could reduce volumetric and mass flow rates, and result in an overall pumping power savings. Nanofluids necessitate smaller heating systems, which are capable of delivering the same amount of thermal energy as larger heating systems using base fluids, but are less expensive; this lowers the initial equipment cost excluding nanofluid cost. This will also reduce environmental pollutants because smaller heating units use less power, and the heat transfer unit has less liquid and material waste to discard at the end of its life cycle.

10/01711 Chaotic behavior of pulsating heat pipes

Song, Y. and Xu, J. *International Journal of Heat and Mass Transfer*, 2009, 52, (13–14), 2932–2941.

Chaotic behaviour of closed loop pulsating heat pipes (PHPs) was studied. The PHPs were fabricated by capillary tubes with outer and inner diameters of 2.0 and 1.20 mm. FC-72 and deionized water were used as the working fluids. Experiments cover the following data ranges: number of turns of 4, 6, and 9, inclination angles from 5° (near horizontal) to 90° (vertical), charge ratios from 50% to 80%, heating powers from 7.5 to 60.0 W. The non-linear analysis is based on the recorded time series of temperatures on the evaporation, adiabatic, and condensation sections. The present study confirms that PHPs are deterministic chaotic systems. Autocorrelation functions (ACF) are decreased versus time, indicating prediction ability of the system is finite. Three typical attractor patterns are identified. Hurst exponents are very high, i.e. from 0.85 to 0.95, indicating very strong persistent properties of PHPs. Curves of correlation integral versus radius of hypersphere indicate two linear sections for water PHPs, corresponding to both high frequency, low amplitude, and low frequency, large amplitude oscillations. At small inclination angles near horizontal, correlation dimensions are not uniform at different turns of PHPs. The non-uniformity of correlation dimensions is significantly improved with increases in inclination angles. Effect of inclination angles on the chaotic parameters is complex for FC-72 PHPs, but it is certain that correlation dimensions and Kolmogorov entropies are increased with increases in inclination angles. The optimal charge ratios are about 60–70%, at which correlation dimensions and Kolmogorov entropies are high. The higher the heating power, the larger the correlation dimensions and Kolmogorov entropies are. For most runs, large correlation dimensions and Kolmogorov entropies correspond to small thermal resistances, i.e. better thermal performance, except for FC-72 PHPs at small inclination angles of $\theta < 15°$.

10/01712 Economic feasibility for acquisition of efficient refrigerators in Brazil

Cardoso, R. B. *et al. Applied Energy*, 2010, 87, (1), 28–37.

Since 1993, the Brazilian National Program of Electricity Conservation has been developing the PROCEL Label Program, oriented towards helping consumers to buy more efficient home appliances. In this context, an energy savings of 1379 GWh and a reduction of 197 MW in the Brazilian demand in 2007 are estimated as a result of efficiency labelling in refrigerators and freezers. This paper aims to evaluate the economic feasibility of purchasing labelled refrigerators instead of inefficient ones, from the consumer's point of view, considering actual market conditions and buying in cash or financing. The evaluation of energy saving was done for 22 different models of refrigerators and the economy was calculated considering the retail price in the Brazilian market and two actual electricity tariffs, taking into account, respectively, high and low household electricity consumption. The effect of ambient temperature on refrigerator performance was evaluated in two conditions: according to the Brazilian standard for performance tests (32 °C) and using the average temperature of southern Brazil (18 °C), the mildest region. The benefit in buying labelled refrigerators was evaluated using the internal rate of return and the payback time for a cash flow during the appliance life, estimated as 16 years. The results indicate that for cash purchase, for any electricity tariff and for both ambient temperatures studied, the consumers are economically benefited buying labelled refrigerators instead of less efficient models. For credit purchases, in the evaluated conditions, high-tariff consumer typically gains selecting labelled refrigerator, on the other hand, for low-tariff consumer and in colder areas, it is economically advisable to buy less efficient appliances. Sensitivity analysis of energy tariff and financing conditions are presented.

10/01713 Electric energy saving potential by substitution of domestic refrigerators in Mexico

Arroyo-Cabañas, F. G. *et al. Energy Policy*, 2009, 37, (11), 4737–4742.

This study evaluates the potential for electric power saving in Mexico that would follow the substitution of old, low efficiency domestic refrigerators with modern, high efficiency ones. The results indicate that a total substitution of domestic refrigerators would save 4.7 TWh/year, which represents 33% of the annual total consumption of 14.1 TWh. Assuming an average daily use of 14 h for domestic refrigeration, 900 MW of electricity would be saved. An annual substitution of 20% over 5 years would save approximately 1 TWh a year and almost 180 MW would be released. It is recommended that this programme of replacement should be supported by the federal and state governments, beginning with the states (which have more direct influence), and with the oldest, least efficient refrigerators along the lines followed in programs that introduced fluorescent compact lamps.

10/01714 Energy consumption for heating and rebound effects

Hens, H. *et al. Energy and Buildings*, 2010, 42, (1), 105–110.

When comparing calculated heating consumption in residential buildings assuming standard usage with standardized measured data, then the two typically does not fit. In fact, measured consumption may be a fraction only of what was calculated. The reason is direct rebound behaviour by the inhabitants. The paper shows the importance of direct rebound through measured results. First temperatures, recorded in daytime and sleeping rooms in a sample of dwellings, are discussed. Then follows a discussion of the indoor temperatures found when calculated energy consumptions for heating were forced to give the same numbers as measured. Next, two small-scale analyses of energy data gained in low-income estates are reviewed, followed by test results on direct rebound in two dwellings, one non-insulated, the other well insulated. These data prove that the benefits of direct rebound are much larger in non-insulated than in well-insulated homes. This fact is used to construct a rebound curve, starting from the normalized consumption data gained in 964 houses. The effect of energy price on direct rebound is also shown.

10/01715 Experimental evaluation of a climate façade: energy efficiency and thermal comfort performance

Serra, V. *et al. Energy and Buildings*, 2010, 42, (1), 50–62.

The results of an extensive experimental campaign on a climate façade with a mechanically ventilated air gap, carried out at the Department of Energetics at the Politecnico di Torino, are presented. Measurements were performed utilizing the TWINS (testing window innovative systems) test facility, which consists of two outdoor cells, one used for reference purposes, and the other which adopts different active façade configurations. The energy efficiency of the façade and the thermal comfort implications have been evaluated considering the ability to pre-heat the ventilation air in the winter season, and the ability to remove part of the solar load during the summer season; the normalized daily energy passing through the façade and the normalized surface temperature of the inner glass were analysed. The improvement in performance obtained by varying the configuration and operative conditions (changing the air flow rate, the shading device and the internal glazing) has been investigated.

10/01716 Experimental investigation on heat transportation over long distance by ammonia–water absorption cycle

Lin, P. *et al. Energy Conversion and Management*, 2009, 50, (9), 2331–2339.

An ammonia–water absorption cycle is suggested to transport heat over long distances, in which thermal energy is transferred into chemical energy in the heat source site by the change of solution concentration. There is then no heat insulation requirement for the transportation pipelines. In the user site the chemical energy could be released with heating or cooling. An experimental prototype has been built to investigate the system performance. The experiments include two parts: heating is obtained from the absorber (user site) in transition season by the ammonia–water absorption heat pump cycle, in which a hot water outlet temperature at about 64 °C can be reached and the system COP is 0.47 (absorption temperature at 66 °C). Cooling is obtained from the evaporator (user site) in summer by the ammonia–water absorption refrigeration cycle, in which a chilled medium outlet temperature at about 8 °C can be reached and the system COP is 0.43 (evaporation temperature at 4.6 °C). The investigation of the transportation parameters also shows that the pump electric consumption can be reduced greatly in comparison with the conventional heat transportation method. The ammonia–water absorption cycle is a potential and efficient way of heat transportation over long distances.

10/01717 Heat transfer characteristics of microencapsulated phase change material slurry in laminar flow under constant heat flux

Zeng, R. *et al. Applied Energy*, 2009, 86, (12), 2661–2670.

Due to its large apparent specific heat during the phase change period, microencapsulated phase change material slurry (MPCMS) has been suggested as a medium for heat transfer. This study investigates experimentally and numerically the convective heat transfer characteristics of MPCMS flowing in a circular tube. The enhanced convective heat transfer mechanism of MPCMS, especially in the thermal fully developed range, was analysed by using the enthalpy model. Three kinds of fluid–pure water, micro-particle slurry and MPCMS were numerically investigated. The results show that in the phase change heat transfer region the Ste number and the Mr number are the most important parameters influencing the Nusselt number fluctuation profile and the dimensionless wall temperature. Re_b, d_p and c also influence the Nusselt number profile and the dimensionless wall temperature, but they are independent of phase change process.

10/01718 Measurement and model on thermal conductivities of carbon nanotube nanorefrigerants

Jiang, W. *et al. International Journal of Thermal Sciences*, 2009, 48, (6), 1108–1115.

The objective of this study is to test thermal conductivity characteristics of CNT nanorefrigerants and to build a model for predicting the thermal conductivities of CNT nanorefrigerants. The influences of CNT diameters and CNT aspect ratios on nanorefrigerant's thermal conductivity were reflected in the experiments, and R113 was used as the host refrigerant for the convenience of the experiments. The experimental results show that the thermal conductivities of CNT nanorefrigerants are much higher than those of CNT–water nanofluids or spherical-nanoparticle-R113 nanorefrigerants. Experiments also show that the smaller the diameter of CNT is or the larger the aspect ratio of CNT is, the larger the thermal conductivity enhancement of CNT nanorefrigerant is. The existent models for predicting thermal conductivity of CNT nanofluid, including Hamilton–Crosser model, Yu–Choi model and Xue model, were verified by the experimental data of CNT nanorefrigerants' thermal conductivities. The verification shows that Yu–Choi model has the mean deviation of 15.1% and it is more accurate than the other two models. A modified Yu–Choi model was presented by improving the empirical constant of Yu–Choi model, and the mean deviation of the modified Yu–Choi model from the experimental results is 5.5%.

10/01719 Microencapsulated *n*-octacosane as phase change material for thermal energy storage

Sari, A. *et al. Solar Energy*, 2009, 83, (10), 1757–1763.

This study deals with preparation and characterization of polymethylmetracrylate (PMMA) microcapsules containing *n*-octacosane as phase change material for thermal energy storage. The surface morphology, particle size and particle size distribution (PSD) were studied by scanning electron microscopy (SEM). The chemical characterization of PMMA/octacosane microcapsules was made by FT-IR spectroscopy method. Thermal properties and thermal stability of microencapsulated octacosane were determined using differential scanning calorimetry (DSC) and thermal gravimetric analysis (TGA). The melting and freezing temperatures and the latent heats of the microencapsulated octacosane as PCM were measured as 50.6 and 53.2 °C, 86.4 and −88.5 J/g, respectively, by DSC analysis. TGA analysis indicated that the microencapsulated octacosane degrade in two steps and had good chemical stability. Thermal cycling test shows that the microcapsules have good thermal reliability with respect to the accelerated thermal cycling. Based on the results, it can be considered that the microencapsulated octacosane have good energy storage potential.

10/01720 Parametric analysis for a new combined power and ejector–absorption refrigeration cycle

Wang, J. *et al. Energy*, 2009, 34, (10), 1587–1593.

A new combined power and ejector–absorption refrigeration cycle is proposed, which combines the Rankine cycle and the ejector–absorption refrigeration cycle, and could produce both power output and refrigeration output simultaneously. This combined cycle, which originates from the cycle proposed by authors previously, introduces an ejector between the rectifier and the condenser, and provides a performance improvement without greatly increasing the complexity of the system. A parametric analysis is conducted to evaluate the effects of the key thermodynamic parameters on the cycle performance. It is shown that heat source temperature, condenser temperature, evaporator temperature, turbine inlet pressure, turbine inlet temperature, and basic solution ammonia concentration have significant effects on the net power output, refrigeration output and exergy efficiency of the combined cycle. It is evident that the ejector can improve the performance of the combined cycle proposed by authors previously.

10/01721 Performance limit analysis of Recooled Cycle for regenerative cooling systems

Bao, W. *et al. Energy Conversion and Management*, 2009, 50, (8), 1908–1914.

This paper presents a new cooling cycle called recooled cycle (RC) for systems with active cooling and demonstrates how coolant could be utilized for secondary cooling through the transfer of enthalpy from coolant to work with an indirect increase in the coolant cooling capacity (heat sink), without any property change in the coolant. The basic concept and working principle are introduced; a thermodynamic cycle analysis is performed to demonstrate the system performance gains with RC over the conventional system with regenerative cooling. Using the principle of thermodynamics, performance potential analysis of RC is performed; expression of performance limit is obtained by deduction. Numerical analysis results further reveal the potential performance of RC taking scramjet engine with RC as the example. Results show that RC is with great potential performance and scientific feasibility. It can increase coolant heat sink and correspondingly reduce the coolant flow for cooling. In addition, the power output of RC could provide energy supply for subsystems.

10/01722 Performance of heat pumps charged with R170/R290 mixture

Park, K.-J. and Jung, D. *Applied Energy*, 2009, 86, (12), 2598–2603.

In this study, the thermodynamic performance of R170/R290 mixture is measured on a heat pump bench tester in an attempt to substitute R22. The bench tester is equipped with a commercial hermetic rotary compressor providing a nominal capacity of 3.5 kW. All tests are conducted under the summer cooling and winter heating conditions of 7/45 °C and −7/41 °C in the evaporator and condenser, respectively. During the tests, the composition in R170/R290 mixture is varied from 0% to 10% with an interval of 2%. Test results show that the coefficient of performance (COP) and capacity of R290 are up to 15.4% higher and 7.5% lower, respectively than those of R22 for two conditions. For R170/R290 mixture, the COP decreases and the capacity increases with an increase in the composition of R170. The mixture of R170/R290 mixture at 4%/96% composition shows the similar capacity and COP as those of R22. For the mixture, the compressor discharge temperature is 17–28 °C lower than that of R22. For R170/R290 mixture, there is no problem with mineral oil since the mixture is composed of hydrocarbons. The amount of charge is reduced up to 58% as compared to R22. Overall, R170/R290 mixture is a good long term 'drop-in' candidate from the view point of energy efficiency and greenhouse warming to replace R22 in residential air-conditioners and heat pumps.

10/01723 Performance prediction of refrigerant-DMF solutions in a single-stage solar-powered absorption refrigeration system at low generating temperatures

He, L. J. *et al. Solar Energy*, 2009, 83, (11), 2029–2038.

A theoretical analysis of the coefficient of performance was undertaken to examine the efficiency characteristics of R22 + DMF, R134a + DMF, R32 + DMF as working fluids, respectively, for a single-stage and intermittent absorption refrigerator which allows the use of heat pipe evacuated tubular collectors. The modelling and simulation of the performance considers both solar collector system and the absorption cooling system. The typical meteorological year file containing the weather parameters for Hangzhou is used to simulate the system. The results show that the system is in phase with the weather. In order to increase the reliability of the system, a hot water storage tank is essential. The optimum ratio of storage tank per solar collector area for Hangzhou's climate for a 1.0 kW system is 0.035–0.043L. Considering the relative low pressure and the high coefficient of performance, R134a + DMF mixture presents interesting properties for its application in solar absorption cycles at moderate condensing and absorbing temperatures when the evaporating temperatures in the range from 278 K to 288 K which are highly useful for food preservation and for air-conditioning in rural areas.

10/01724 Simulation models for the analysis of space heat consumption of buildings

Popescu, D. *et al. Energy*, 2009, 34, (10), 1447–1453.

This study develops and analyses an original methodology for the simulation and prediction of space heating energy consumption in buildings connected to a district heating system, characterized by lack of individual control systems for end-users. The identification of the input parameters is based on both classical engineering equations and statistical analysis of collected data. Two main factors play important roles in the model: (1) climate and (2) human behaviour. Model validation was undertaken through the analysis of field data collected during the winter, via a monitoring system working in a partially-controlled district heating system. The comparison between the results obtained with the proposed model versus classical methods points out the possibility to implement, using the proposed methodology, management policies for a district that offer significant cost-effective energy savings opportunities.

10/01725 Simulation of a photovoltaic/thermal heat pump system having a modified collector/evaporator

Xu, G. *et al. Solar Energy*, 2009, 83, (11), 1967–1976.

A new photovoltaic/thermal heat pump (PV/T-HP) system having a modified collector/evaporator (C/E) has been developed and numerically studied. Multi-port flat extruded aluminium tubes were used in the modified C/E, as compared to round copper tubes used in a conventional C/E. Simulation results suggested that a better operating performance can be achieved for a PV/T-HP system having such a modified C/E. In addition, using the meteorological data in both Nanjing and Hong Kong, China, the simulation results showed that this new PV/T-HP system could efficiently generate electricity and thermal energy simultaneously in both cities all-year-round. Furthermore, improved operation by using variable speed compressor has been designed and discussed.

10/01726 Study of a phase change energy storage using spherical capsules. Part I: experimental results

Bédécarrats, J. P. *et al. Energy Conversion and Management*, 2009, 50, (10), 2527–2536.

This paper presents an experimental investigation of the performance of an encapsulated phase change energy storage during the charging and the discharging processes. The spherical capsules, containing water with a nucleation agent as a phase change material (PCM), fill the thermal storage tank. The heat transfer fluid which circulates through the tank and around the capsules is an aqueous solution of monoethylene glycol. A series of experiments were carried out to investigate the effects of various parameters including the inlet heat transfer fluid temperature and flow rate, kinetics of cooling and heating, on the charging and discharging processes. The main results are: that there is a significant influence of the supercooling phenomenon during the charging process; the lower the inlet coolant temperature and the larger the coolant flow rate are, the faster the storage is, the choice of the couples (flow rate, inlet temperature) must permit storage of the total energy in a given time; and when a charge mode follows an incomplete discharge mode, the charge mode is the result of the crystallization of some capsules which present supercooling and of others which do not, the consequence is that the charge mode is made at a higher temperature with a relatively shorter duration.

10/01727 Study of a phase change energy storage using spherical capsules. Part II: numerical modelling

Bédécarrats, J. P. *et al. Energy Conversion and Management*, 2009, 50, (10), 2537–2546.

The objective of this work is the numerical study of an industrial process of energy storage which consists in the use of a cylindrical tank filled with encapsulated phase change materials (PCM). A particularity is present in this kind of processes; it concerns the delay of the crystallization of the PCM, called supercooling phenomenon. The development of the model for cold storage with heat transfer fluid flowing enables a detailed analysis of this process. The effects of different parameters on the behaviour of the tank, such as the inlet temperature, the flow rate, are examined when the tank is in vertical position. There is substantial agreement between the prediction and the experimental values already presented in part I.

10/01728 The impact of auxiliary energy on the efficiency of the heating and cooling system: monitoring of low-energy buildings

Kalz, D. E. *et al. Energy and Buildings*, 2009, 41, (10), 1019–1030.

This paper presents a detailed meta-analysis of end and primary energy use for heating, cooling and ventilation of 11 low-energy non-residential buildings and one residential building in Germany that belong to the EnOB research program launched by the German Federal Ministry for Economy. In particular, the analysis emphasizes the substantial impact of auxiliary energy use on the efficiency of heating and cooling performance. The investigated buildings employ environmental energy sources and sinks – such as the ground, ground water, rainwater and the ambient air – in combination with thermo-active building systems. These concepts are promising approaches for slashing the primary energy use of buildings without violating occupant thermal comfort. A limited primary energy use of about 100 $\mathrm{kWh_{prim}/(m^2_{net}a)}$ as a target for the complete building service technology (HVAC and lighting) was postulated for all buildings presented. With respect to this premise, a comprehensive long-term monitoring in high time resolution was carried out over the course of two to five years, with an accompanying commissioning of the building performance. Measurements include the energy use for heating, cooling, and ventilation, as well as the auxiliary equipment, the performance of the environmental heat source and sink, and local climatic site conditions.

10/01729 Thermal performance of packed bed thermal energy storage units using multiple granular phase change composites

Rady, M. *Applied Energy*, 2009, 86, (12), 2704–2720.

The present article reports on the utilization of multiple granular phase change composites (GPCC) with different ranges of phase change temperatures in a packed bed thermal energy storage system. Small particle diameter of GPCC allows simple mixing of two or three ranges of GPCCs in a packed bed for enhancement of storage unit performance. Experiments have been carried out to characterize the phase changing characteristics of two GPCCs chosen for this purpose. Packed bed column experiments have been carried out to provide basic understanding of the heat transfer process in the composite bed consisting of a mixture of GPCCs at different values of mixing ratio. A mathematical model has been developed for the analysis of charging and discharging process dynamics. Once validated, the model has been used to perform a parametric study to investigate the overall bed performance at different values of mixing ratio and Reynolds number. An optimization of the value of mixing ratio has been obtained based on the overall charging and discharging times as well as the exergy efficiency. It has been demonstrated that, as compared to the use of single GPCC, careful choice of the mixing ratio of GPCCs in a composite bed can result in a significant enhancement of the overall storage unit performance. As compared to the use of multiple sequential layers of GPCCs, using units composed of a mixture of GPCCs with an optimized mixing ratio results in a remarkable improvement of the unit performance without limitations on the charging and discharging directions during practical applications.

10/01730 Two-phase Euler-Lagrange CFD simulation of evaporative cooling in a Wind Tower

Saffari, H. and Hosseinnia, S. M. *Energy and Buildings*, 2009, 41, (9), 991–1000.

A new design of wind tower is investigated numerically under different structural parameters and environmental conditions. The new design is some wetted columns, consisting of wetted curtains hung in the tower column, which are modelled as surfaces that inject droplets of water with very low speed. The CFD open source package – Open FOAM – is used. The current three-dimensional CFD simulation has adopted both the Eulerian approach for the air phase and the Lagrangian approach for the water phase. The effects of water droplet diameter and water droplet temperature on the thermal performance of the wind tower are investigated at specific inlet air velocity and relative humidity and height of wetted columns. Also, the effects of wind velocity, temperature, and relative humidity inlet to wind tower are studied. Changing the height of the wetted columns and its effect on the evaporative cooling in other specific parameters is studied. The results obtained from the present CFD study are compared with the analytical data taken from the literature and a good agreement is observed. As a result, the height of 10 m of wetted columns decreases 12 K of the ambient air temperature and increases 22% of its relative humidity.

10/01731 Unsteady fluid mechanics and heat transfer study in a double-tube air–combustor heat exchanger with porous medium

Moraga, N. O. *et al. International Journal of Heat and Mass Transfer*, 2009, 52, (13–14), 3353–3363.

Fluid mechanics and heat transfer are studied in a double-tube heat exchanger that uses the combustion gases from natural gas in a porous medium located in a cylindrical tube to warm up air that flows through a cylindrical annular space. The mathematical model is constructed based on the equations of continuity, linear momentum, energy and chemical species. Unsteady fluid mechanics and heat transfer by forced gas convection in the porous media, with combustion in the inner tube, coupled to the forced convection of air in the annular cylindrical space are predicted by use of finite volumes method. Numerical simulations are made for four values of the annular air flow Reynolds number in the range $100 \leq Re \leq 2000$, keeping constant the excess air $\psi = 4.88$, the porosity $\varepsilon = 0.4$, and the air–fuel mixture inlet speed $Uo = 0.43$ m/s. The results obtained allow the characterization of the velocity and temperature distributions in the inner tube and in the annular space, and at the same time to describe the displacement of the moving combustion zone and the annular porous media heat exchanger thermal efficiency. It is concluded that the temperature increase is directly related to the outer Reynolds number.

10/01732 Urban heat island characteristics in London during winter

Giridharan, R. and Kolokotroni, M. *Solar Energy*, 2009, 83, (9), 1668–1682.

This paper presents results characterizing the urban heat island intensity (UHI) in London during the peak winter season. Most UHI studies focus on the phenomenon during the summer as this is the period when temperature peaks are observed. However, for urban planning mitigation strategies and building energy demand design, the heating season should be also considered, since proposed measures to alleviate the summer UHI might have a negative effect during the winter or intermediate seasons. The study carries out trend and regression analysis by controlling climatic and geographical variations in the data set following a methodology developed for studying summer UHI. It was found that average nocturnal UHI of winter periods are of similar magnitude to the summer periods but the peak winter UHI trends are not as regular as summer giving a first indication that the effect of climate and urban parameters is different. The regression analysis in this research uses six on-site variables namely aspect ratio, surface albedo, plan density ratio, green density ratio, fabric density ratio and thermal mass to carry out impact investigation in six data sets, categorized by three geographical location within London and three sky conditions and regional wind velocity. The above variables do not explain the changes in outdoor temperature as much as they did during summer period models. However, unlike summer, the winter climate control models have the same R^2 indicating that most of changes in outdoor temperature are caused by climate factors and not the on-site variables.

10/01733 Urban heat island in southern Europe: the case study of Hania, Crete

Kolokotsa, D. *et al. Solar Energy*, 2009, 83, (10), 1871–1883.

This study analyses the results of the urban heat island (UHI) research for a coastal densely built small Mediterranean town namely Hania, Crete, Greece. The specific research targets to verify the existence, the intensity, the size and the form of the UHI phenomenon in the specific region as well as to understand its correlation with the local weather conditions. Nine urban and three rural meteorological stations are used for this study. Temperature and relative humidity measurements are collected from 26 May 2007 until 24 October 2007. In parallel, meteorological data including wind speed and direction, barometric pressure, sunlight and precipitation for the specific region are collected and elaborated for cross-correlation with the appearance of the UHI phenomenon. During summer period, where the temperature is high, the UHI takes its maximum intensity, of about 8 °C. Also, the form of the UHI is strongly influenced from the wind speed and direction. The northern winds expand the UHI front, while the western winds contribute to the UHI reduction. Finally the discomfort index (DI) is calculated for the 2007 summer period to indicate the outdoor living conditions.

10/01734 Warm homes: drivers of the demand for heating in the residential sector in New Zealand

Howden-Chapman, P. *et al. Energy Policy*, 2009, 37, (9), 3387–3399.

New Zealand houses are large, often poorly constructed and heated, by OECD standards, and consequently are colder and damper indoors than recommended by the World Health Organization. This affects both the energy consumption and the health of households. The traditional New Zealand household pattern of only heating one room of the house has been unchanged for decades, although there has been substantial market penetration of unflued gas heaters and more recently heat pumps. This paper describes the residential sector and the results of two community-based trials of housing and heating interventions that have been designed to measure the impact of (1) retrofitting insulation and (2) replacing unflued gas heaters and electric resistance heaters with heat pumps, wood pellet burners and flued gas heaters. The paper describes findings on the rebound effect or 'take-back' – the extent to which households take the gains from insulation and heating improvements as comfort (higher temperatures) rather than energy savings, and compares energy-saving patterns with those suggested by an earlier study. Findings on these aspects of household space heating are discussed in the context of the New Zealand government's policy drive for a more sustainable energy system, and the implications for climate change policy.

11 ENGINES

Power generation and propulsion, electrical vehicles

10/01735 A new approach for enhancing performance of a gas turbine (case study: Khangiran refinery)

Farzaneh-Gord, M. and Deymi-Dashtebayaz, M. *Applied Energy*, 2009, 86, (12), 2750–2759.

There are various methods which are commercially available for turbine air inlet cooling aiming to improve gas turbine efficiency. In this study a new approach has been proposed to improve performance of a gas turbine. The approach has been applied to one of the Khangiran refinery gas turbines. The idea is to cool inlet air of the gas turbine by potential cooling capacity of the refinery natural-gas pressure drop station. The study is part of a comprehensive program aimed to enhance gas turbines performance of the Khangiran gas refinery. The results show that the gas turbine inlet air temperature could be reduced in range of 4–25 K and the performance could be improved in range of 1.5–5% for almost 10 months.

10/01736 Cotton methyl ester usage in a diesel engine equipped with insulated combustion chamber

Hazar, H. *Applied Energy*, 2010, 87, (1), 134–140.

An important alternative for diesel fuel is methyl ester made of vegetable oils. Direct use these fuels without modification in diesel engines causes some damages on the parts of the engines and also, the viscosity of the methyl ester fuels is quite higher than that of diesel fuel (No. 2D) and their calorific value is lower. Therefore it is not possible to obtain more benefit. Coating combustion chamber parts with a ceramic material seems an effective solution for improving performance of these lower-quality fuels compared with No. 2D and also exhaust emission values. Since it allows to use higher combustion temperatures. In the present study, surfaces of cylinder head, piston, exhaust and inlet valve of a four-stroke, direct injection, single cylinder diesel engine were coated with molybdenum (Mo) by plasma spray method. Thus, thermal barrier characteristic was brought to these parts. Variances in performance and emission values of cotton methyl ester and 2D fuel mixtures were studied in the ceramic coated and uncoated engines under the same running conditions. Performance (up to 2.2–2.3% for engine power, up to 3.5–5.6% for specific fuel consumption) and emission values (up to 17–22% for CO, up to 5.2–10% for smoke) of the test fuels were improved in the coated engine compared with the uncoated engine. However, because the coated engine ran at higher temperatures compared with the uncoated engine, an increase (up to 6.5–7.4%) was seen in NO_x emission in cases of all test fuels.

10/01737 Diagnosis methodology for the turbocharger groups installed on a 1 MW internal combustion engine

Barelli, L. *et al. Applied Energy*, 2009, 86, (12), 2721–2730.

The issue of internal combustion engine (ICE) diagnosis attracts great interest because modern engines need continual control of the operational status, in order to obtain high efficiency in energy conversion and accurate control of the polluting emissions. In particular, in reference to an alternative ICE of 1 MW, the present study relates the development, through the design of neural simulators, of the turbocharger maps to reproduce the operational states characterized by 'new&clean' conditions and allowing the evaluation of particular 'health state' indices of such a module. In detail, after an experimental campaign, turbocharger fundamental characteristics referred to 'new&clean' conditions, such as the compressor isoentropic efficiency and the mass flow elaborated by the turbine, were evaluated at different operation conditions of the alternative ICE. Subsequently, the neural simulators were developed through the training and test of different neural architectures.

10/01738 Evaluation of the effect of engine, load and turbocharger parameters on transient emissions of diesel engine

Rakopoulos, C. D. *et al. Energy Conversion and Management*, 2009, 50, (9), 2381–2393.

The vital issue of exhaust emissions during transient operation of diesel engines has been studied so far mainly on an experimental rather than simulation basis, owing to the very high computational times required for the analysis of each transient cycle. The study of transient emissions, however, is extremely important to manufacturers, since newly produced engines must meet the stringent regulations concerning exhaust emissions levels. In the present work, a comprehensive two-zone transient diesel combustion model is used for a preliminary evaluation of the effect of various parameters on nitric oxide (NO) and soot emissions during transient operation after load changes. The parameters are divided into three categories according to the specific sub-system examined, i.e. engine, load and turbocharger. Demonstrative diagrams are provided for the development of NO and soot emissions during the transient event, which depict the effect of each parameter considered. Moreover, the peculiarities of each case are discussed mainly in relation to turbocharger lag effects. For the current engine-load configuration, it is found that exhaust valve opening timing and cylinder wall insulation affect considerably NO and soot emissions. Additionally, load characteristics as well as turbocharger (T/C) mass moment of inertia play an important role on the development of transient NO and soot emissions.

10/01739 Nine-step phenomenological diesel soot model validated over a wide range of engine conditions

Tao, F. *et al. International Journal of Thermal Sciences*, 2009, 48, (6), 1223–1234.

A nine-step phenomenological soot model has been implemented into the KIVA-3V code for predicting soot formation and oxidation processes in diesel engines. The model involves nine generic steps, i.e. fuel pyrolysis, precursor species (including acetylene) formation and oxidation, soot particle inception, particle coagulation, surface growth and oxidation. The fuel pyrolysis process leads to acetylene formation and it is described by a single-step reaction. The particle inception occurs via a generic gas-phase precursor species, and the precursor is the product of an irreversible reaction from acetylene. The acetylene addition reaction contributes to soot surface growth. The particle coagulation affects both particle size and number density. The oxidation of soot particles includes two mechanisms – Nagle and Strickland-Constable's O_2 oxidation mechanism and Neoh and colleagues' OH oxidation mechanism. The quasi-steady state assumption is applied to an H_2–O_2–CO system for calculating OH concentration. Both acetylene and precursor species have their own consumption paths, each of which is described by a single-step oxidation reaction. Validations of the model have been conducted over a wide range of engine conditions from conventional to PCCI-like combustion. Two engine examples (a heavy-duty diesel engine and a light-duty diesel engine) are presented in this paper. The predictions are compared against measurements, and the applicability of the model to multi-dimensional diesel simulations is assessed. The model's capability of predicting the soot distribution structure in a conventional diesel flame is included in discussion as well. The work reveals that the nine-step model is not only computationally efficient but also fundamentally sound. The model can be applied to diesel engine combustion analysis and, after calibration, is suitable to be integrated with genetic algorithms for system optimization over a controllable range of operations.

Hybrid engine systems

10/01740 A conceptual framework for the *vehicle-to-grid* (*V2G*) implementation

Guille, C. and Cross, G. *Energy Policy*, 2009, 37, (11), 4379–4390.

The paper focuses on presenting a proposed framework to effectively integrate the aggregated battery vehicles into the grid as distributed energy resources to act as controllable loads to levelize the demand on the system during off-peak conditions and as a generation/storage device during the day to provide capacity and energy services to the grid. The paper also presents practical approaches for two key implementation steps – computer/communication/control network and incentive program.

10/01741 CFD simulation study to investigate the risk from hydrogen vehicles in tunnels

Middha, P. and Hansen, O. R. *International Journal of Hydrogen Energy*, 2009, 34, (14), 5875–5886.

When introducing hydrogen-fuelled vehicles, an evaluation of the potential change in risk level should be performed. It is widely accepted that outdoor accidental releases of hydrogen from single vehicles will disperse quickly, and not lead to any significant explosion hazard. The situation may be different for more confined situations such as parking garages, workshops, or tunnels. Experiments and computer modelling are both important for understanding the situation better. This article reports a simulation study to examine what, if any, is the explosion risk associated with hydrogen vehicles in tunnels. Its aim was to further the understanding of the phenomena surrounding hydrogen releases and combustion inside road tunnels, and furthermore to demonstrate how a risk assessment methodology developed for the offshore industry could be applied to the current task. This work is contributing to the EU Sixth Framework (Network of Excellence) project HySafe, aiding the overall understanding that is also being collected from previous studies, new experiments and other modelling activities. Releases from hydrogen cars (containing 700 bar gas tanks releasing either upwards or downwards or liquid hydrogen tanks releasing only upwards) and buses (containing 350 bar gas tanks releasing upwards) for two different tunnel layouts and a range of longitudinal ventilation conditions have been studied. The largest release modelled was 20 kg H_2 from four cylinders in a bus (via one vent) in 50 s, with an initial release rate around 1000 g/s. Comparisons with natural gas-fuelled vehicles have also been performed. The study suggests that for hydrogen vehicles a typical worst-case risk assessment approach assuming the full gas inventory being mixed homogeneously at stoichiometry could lead to severe explosion loads. However, a more extensive study with more realistic release scenarios reduced the predicted hazard significantly. The flammable gas cloud sizes were still large for some of the scenarios, but if the actual reactivity of the predicted clouds is taken into account, moderate worst-case explosion pressures are predicted. As a final step of the risk assessment approach, a probabilistic QRA study is performed in which probabilities are assigned to different scenarios, time-dependent ignition modelling is applied, and equivalent stoichiometric gas clouds are used to translate reactivity of dispersed non-homogeneous clouds. The probabilistic risk assessment study is based on over 200 dispersion and explosion CFD calculations using the commercially available tool FLACS. The risk assessment suggested a maximum likely pressure level of 0.1–0.3 barg at the pressure sensors that were used in the study. Somewhat higher pressures are seen elsewhere due to reflections (e.g. under the vehicles). Several other interesting observations were found in the study. For example, the study suggests that for hydrogen releases the level of longitudinal tunnel ventilation has only a marginal impact on the predicted risk, since the momentum of the releases and buoyancy of hydrogen dominates the mixing and dilution processes.

10/01742 Combustion characteristics of a 4-stroke CI engine operated on Honge oil, Neem and Rice Bran oils when directly injected and dual fuelled with producer gas induction

Banapurmath, N. R. *et al. Renewable Energy*, 2009, 34, (7), 1877–1884.

Increasing petroleum fuel costs have led to a growing interest in alternative fuels, in order to provide a suitable substitute to diesel for a compression ignition (CI) engine. The vegetable oils present a promising alternative fuel to diesel oil since they are renewable, biodegradable and clean burning, with similar properties to that of diesel. They offer almost same power output with slightly lower thermal efficiency due to their lower energy content compared to diesel. Utilization of producer gas in a CI engine on dual fuel mode provides an effective approach towards conservation of diesel fuel. Gasification involves conversion of solid biomass into combustible gases, which completes combustion in a CI engines. Hence the producer gas can act as promising alternative fuel and it has high octane number (100–105) and calorific value (5–6 MJ/N m^3). Its simpler structure with low carbon content results in a substantial reduction of exhaust emission. Downdraft moving bed gasifier coupled with compression ignition engine are a good choice for moderate quantities of available mass up to 500 kW of electrical power. Hence bio-derived gas and vegetable liquids appear more attractive in view of their friendly environmental nature. Experiments have been conducted on a single cylinder, four-stroke, direct injection, water-cooled CI engine operated in single fuel mode using Honge, Neem and Rice Bran oils. In dual fuel mode combinations of producer gas and three oils were used at different injection timings and injection pressures. Dual fuel mode of operation resulted in poor performance at all the loads when compared with single fuel mode at all injection timings tested. However, the brake thermal efficiency is improved marginally when the injection timing was advanced. Decreased smoke, NO_x emissions and increased CO emissions were observed for dual fuel mode for all the fuel combinations compared to single fuel operation.

10/01743 Hydrous ethanol vs. gasoline-ethanol blend: engine performance and emissions

Costa, R. C. and Sodré, J. R. *Fuel*, 2010, 89, (2), 287–293.

This work compares the performance and emissions from a production 1.0-l, eight-valve, and four-stroke engine fuelled by hydrous ethanol (6.8% water content in ethanol) or 78% gasoline–22% ethanol blend. The engine was tested in a dynamometer bench in compliance with NBR/ISO 1585 standard. The performance parameters investigated were torque, brake mean effective pressure (BMEP), brake power, specific fuel consumption (SFC), and thermal efficiency. Carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbons (HC) and oxides of nitrogen (NO_X) exhaust emissions levels are also presented. The results showed that torque and BMEP were higher when the gasoline–ethanol blend was used as fuel on low engine speeds. On the other hand, for high engine speeds, higher torque and BMEP were achieved when hydrous ethanol fuel was used. The use of hydrous ethanol caused higher power at high engine speeds, whereas, for low engine speeds, both fuels produced about the same power. Hydrous ethanol produced higher thermal efficiency and higher SFC than the gasoline–ethanol blend throughout all the engine speed range studied. With regard to exhaust emissions hydrous ethanol reduced CO and HC, but increased CO_2 and NO_X levels.

10/01744 Influence of injection timing on performance, emission and combustion characteristics of a DI diesel engine running on waste plastic oil

Mani, M. and Nagarajan, G. *Energy*, 2009, 34, (10), 1617–1623.

Environmental concern and availability of petroleum fuels have caused interests in the search for alternate fuels for internal combustion engines. Waste plastics are indispensable materials in the modern world and application in the industrial field is continually increasing. In this context, waste plastics are currently receiving renewed interest. As an alternative, non-biodegradable, and renewable fuel, waste plastic oil is receiving increasing attention. The waste plastic oil was compared with the petroleum products and found that it can also be used as fuel in compression ignition engines. In the present work, the influence of injection timing on the performance, emission and combustion characteristics of a single cylinder, four stroke, direct injection diesel engine has been experimentally investigated using waste plastic oil as a fuel. Tests were performed at four injection timings (23°, 20°, 17° and 14° bTDC). When compared to the standard injection timing of 23° BTDC the retarded injection timing of 14° bTDC resulted in decreased oxides of nitrogen, carbon monoxide and unburned hydrocarbon while the brake thermal efficiency, carbon dioxide and smoke increased under all the test conditions.

10/01745 Model of a novel pressurized solid oxide fuel cell gas turbine hybrid engine

Burbank, W. *et al. Journal of Power Sources*, 2009, 193, (2), 656–664.

Solid oxide fuel cell gas turbine (SOFC-GT) hybrid systems for producing electricity have received much attention due to high-predicted efficiencies, low pollution and availability of natural gas. Due to the higher value of peak power, a system able to meet fluctuating power demands while retaining high efficiencies is strongly preferable to base load operation. SOFC systems and hybrid variants designed to date have had narrow operating ranges due largely to the necessity of heat management within the fuel cell. Such systems have a single degree of freedom controlled and limited by the fuel cell. This study will introduce a new SOFC-GT hybrid configuration designed to operate over a 5:1 turndown ratio, while maintaining the SOFC stack exit temperature at a constant 1000 °C. The proposed system introduces two new degrees of freedom through the use of a variable-geometry nozzle turbine to directly influence system airflow, and an auxiliary combustor to control the thermal and power needs of the turbomachinery.

Transport battery development

10/01746 Considerations for the selection of an applicable energy efficiency test procedure for electric motors in Malaysia: lessons for other developing countries

Yanti, P. A. A. and Mahlia, T. M. I. *Energy Policy*, 2009, 37, (9), 3467–3474.

Electric motors are a major energy-consuming appliance in the industrial sector. According to a survey, electric motors account for more than 70% of the total growth from 1991 to 2004 in electricity consumption in this sector in Malaysia. To reduce electricity consumption, Malaysia should consider resetting the minimum energy efficiency standards for electric motors sometime in the coming year. The first step towards adopting energy efficiency standards is the creation of a procedure for testing and rating equipment. An energy test procedure is the technical foundation for all energy efficiency standards, energy labels and other related programs. The test conditions in the test procedure must represent the conditions of the country. This paper presents the process for the selection of an energy test procedure for electric motors in Malaysia based on the country's conditions and requirements. The adoption of test procedures for electric motors internationally by several countries is also discussed in this paper. Even though the paper only discusses the test procedure for electric motors in Malaysia, the methods can be directly applied in other countries without major modifications.

10/01747 Electroless-plated tin compounds on carbonaceous mixture as anode for lithium-ion battery

Jhan, Y. R. *et al. Journal of Power Sources*, 2009, 193, (2), 810–815.

A composite anode materials was prepared that contained tin compounds of $Sn_6O_4(OH)_4$, SnO_2 and Sn_3PO_4 on the surface of carbonaceous mixture mesophase graphite particles (MGP) and nature graphite (NG). The nanosize tin compounds were electrolessly plated from aqueous solutions onto the carbonaceous mixture. The morphology and structure of tin compounds were characterized by scanning electron microscopy (SEM) and X-ray diffraction (XRD). It was found that the tin compounds particle size was a crucial factor to improve Sn compounds/Carbon composite anodes for cyclability and reversible capacity. The homogeneous dispersion and smaller particle size of tin compounds was attributed to the additive of NG. As the carbonaceous substrate was C–C mixture carbon, the particle size of Sn compounds was about 20–30 nm. However, the particle size was 100–200 nm, as the carbon substrate was singular MGP. Electrochemical performance test of the Sn compounds/C–C composite electrode shows the maximum specific charge capacity of 583 $mAh\,g^{-1}$ at the fifth cycle. The charge capacity retention of Sn compounds/C–C electrode was 85% after 20 cycles. The reversible capacity of Sn compounds/C–C electrode increased 292 and 97 $mAh\,g^{-1}$ more than pristine (NG + MGP) electrode and Sn compounds/C electrode at the fifth cycle, respectively.

10/01748 Energy management of fuel cell/battery/supercapacitor hybrid power source for vehicle applications

Thounthong, P. *et al. Journal of Power Sources*, 2009, 193, (1), 376–385.

This paper proposes a perfect energy source supplied by a polymer electrolyte membrane fuel cell (PEMFC) as a main power source and storage devices: battery and supercapacitor, for modern distributed generation system, particularly for future fuel cell vehicle applications. The energy in hybrid system is balanced by the dc bus voltage regulation. A supercapacitor module, as a high dynamic and high power density device, functions for supplying energy to regulate a dc bus voltage. A battery module, as a high energy density device, operates for supplying energy to a supercapacitor bank to keep it charged. A FC, as a slowest dynamic source in this system, functions to supply energy to a battery bank in order to keep it charged. Therefore, there are three voltage control loops: dc bus voltage regulated by a supercapacitor bank, supercapacitor voltage regulated by a battery bank, and battery voltage regulated by a FC. To authenticate the proposed control algorithm, a hardware system in the laboratory is realized by analog circuits and numerical calculation by dSPACE. Experimental results with small-scale devices (a PEMFC: 500 W, 50 A; a battery bank: 68 Ah, 24 V; and a supercapacitor bank: 292 F, 30 V, 500 A) corroborate the excellent control principle during motor drive cycle.

10/01749 Multi-electron reaction materials for high energy density batteries

Gao, X.-P. and Yang, H.-X. *Energy & Environmental Science*, 2010, 3, (2), 174–189.

The need for high-energy-density batteries becomes increasingly important for the development of new and clean energy technologies, such as electric vehicles and electrical storage from wind and solar power. The search for new energetic materials of primary and secondary batteries with higher energy density has been highlighted in recent years. This review surveys recent advances in the research field of high energy density electrode materials with focus on multi-electron reaction chemistry of light-weight elements and compounds. It concludes that the number of advanced batteries in industrial development suggests a promising future for these applications. The energy density of 300 $Wh\,kg^{-1}$ is expected to be reached in the next 3–5 years and even higher densities for rechargeable batteries in 10 years.

10/01750 Nickel(II) tetra-aminophthalocyanine modified MWCNTs as potential nanocomposite materials for the development of supercapacitors

Chidembo, A. T. *et al. Energy & Environmental Science*, 2010, 3, (2), 228–236.

The supercapacitive properties of nickel(II) tetraaminophthalocyanine (NiTAPc)/multi-walled carbon nanotube (MWCNT) nanocomposite films have been investigated for the first time and found to possess a maximum specific capacitance of $981 \pm 57\,F\,g^{-1}$ ($200 \pm 12\,mF\,cm^{-2}$), a maximum power density of $700 \pm 1\,W\,kg^{-1}$, a maximum specific energy of 134 ± 8 $Wh\,kg^{-1}$ and excellent stability of over 1500 charge-discharge continuous cycling. Impedimetric study proves that most of the stored energy of the MWCNT-NiTAPc nanocomposite can be accessible at high frequency (720 Hz). When compared to MWCNTs modified with unsubstituted nickel(II) phthalocyanine (MWCNT-NiPc) or nickel(II) tetra-*tert-butyl*phthalocyanine (MWCNT-*t*Bu-NiPc), MWCNT-NiTAPc exhibited superior supercapacitive behaviour, possibly due to the influence of nitrogen-containing groups on the phthalocyanine rings.

10/01751 The feasibility of long range battery electric cars in New Zealand

Duke, M. *et al. Energy Policy*, 2009, 37, (9), 3455–3462.

New Zealand transport accounts for over 40% of the carbon emissions, with private cars accounting for 25%. In the Ministry of Economic Development's recently released 'New Zealand Energy Strategy to 2050', it proposed the widescale deployment of electric vehicles as a means of reducing carbon emissions from transport. However, New Zealand's lack of public transport infrastructure and its subsequent reliance on private car use for longer journeys could mean that many existing battery electric vehicles (BEVs) will not have the performance to replace conventionally fuelled cars. As such, this paper discusses the potential for BEVs in New Zealand, with particular reference to the development of the University of Waikato's long-range UltraCommuter BEV. It is shown that to achieve a long range at higher speeds, BEVs should be designed specifically rather than retrofitting existing vehicles to electric. Furthermore, the electrical energy supply for a mixed fleet of two million BEVs is discussed and conservatively calculated, along with the number of wind turbines to achieve this. The results show that approximately 1350 MW of wind turbines would be needed to supply the mixed fleet of two million BEVs, or 54% of the energy produced from New Zealand's planned and installed wind farms.

12 REFRACTORIES/ CERAMICS

Properties, production, applications

10/01752 Carbon-rich SiCN ceramics derived from phenyl-containing poly(silylcarbodiimides)

Mera, G. *et al. Journal of European Ceramic Society*, 2009, 29, (13), 2873–2883.

Novel phenyl-containing polysilylcarbodiimides were synthesized and their thermolysis and crystallization behaviour up to 2000 °C was investigated. The Si/C ratio of the preceramic polymer was varied in a defined way by starting from dichlorosilanes with different organic substituents, namely R and R′ with R = phenyl and R′ = H, phenyl, methyl or vinyl. Several techniques were employed to study the structural features of the polymers and their thermolysis products. The temperature of crystallization depends on the carbon content of the precursors. Thus, in the sample with the highest carbon content the separation of β-SiC from the amorphous SiCN matrix is observed at $T > 1500\,^{\circ}\mathrm{C}$, resulting in the highest temperature of thermal stability against crystallization ever reported for a SiCN ceramic derived from polysilylcarbodiimides. Moreover, no crystallization of β-Si_3N_4 was observed.

10/01753 Effect of CuO on $CaTiO_3$ perovskite ceramics prepared using a direct sintering process

Liou, Y.-C. *et al. Journal of Nuclear Materials*, 2009, 393, (3), 492–496.

Effect of CuO on $CaTiO_3$ (CT) ceramics prepared using a direct sintering process (reaction-sintering process) was investigated. The mixture of raw materials was pressed and sintered into ceramics without any calcination stage involved. Pure CT could be obtained. The degree of densification in CT via reaction-sintering process is lower than traditional oxide route but the grains grew easier in CT via reaction-sintering process. A density 3.63 g/cm^3 (90.3% of ρ_{th}) is obtained in CT pellets after 1500 °C/16 h sintering. With 3 wt.% CuO addition, density 3.92 g/cm^3 (97.5% of ρ_{th}) is obtained after 8 h sintering at 1500 °C due to the liquid phase sintering. The liquid phase at grain boundaries appeared significantly at a lower sintering temperature for longer soak time.

10/01754 Energy and environmental analysis of glass container production and recycling

Vellini, M. and Savioli, M. *Energy*, 2009, 34, (12), 2137–2143.

This study examines, from an energy and environmental standpoint, glass production for drink containers. The industrial process is first analysed as is, so as to evaluate and assess its energy needs and its associated environmental impact. Then the influence of glass container recycling and reuse on energy consumption and pollutant emission is investigated. To this end the recycling chain operation is illustrated and appropriate working hypotheses for the modified process are formulated, so that its energy and environmental performance can be evaluated. Finally, the two production scenarios are compared by means of life cycle assessment methodology, to the purpose of determining the best recycling percentage for glass containers from the standpoint of energy consumption and pollutant emission minimization, taking also into account the waste legislation currently in force. The model results indicate that glass container production can be more environmentally benign than PET container production only if the reuse and recycle factors are higher than a certain threshold; in the simulation, the glass container production scenario with an 80% reuse factor yields better performances than PET container production, whereas a scenario with a 25% reuse factor fails to do so. Therefore any management policy must carefully take into account the actual possibilities of reuse and recycle in the specific sector considered, in order to plan the most effective strategies from the energy and environmental point of view. The potential of recycling is unquestionable, not only with the perspective of a general improvement of the energy, environmental and technological processes, but also considering the substantial reduction on the environmental impacts considered.

10/01755 Energy performance of a dual airflow window under different climates

Wei, J. *et al. Energy and Buildings*, 2010, 42, (1), 111–122.

Ventilated windows have shown great potential in conserving energy in buildings and provide fresh air to improve indoor air quality. This paper reports the effort to use EnergyPlus to simulate the energy performance of a dual airflow window under different climates. This investigation first developed a network model to account for the two-dimensional heat transfer in the window system and implemented it in EnergyPlus. The two-dimensional assumption and the modified EnergyPlus program were validated by the measured temperatures of the window and the energy demand of a test cell with the window under actual weather conditions. Then EnergyPlus was applied to analyse energy performance of a small apartment installed with the dual airflow windows in five different climate zones in China. The energy used by the apartment with blinds windows and low-e windows was also calculated for comparison. The dual airflow window can reduce heating energy of the apartment, especially in cold climate. The cooling energy reduction by the window was less important than that by shading solar radiation. The dual airflow window is recommended for colder climate. If improving air quality is a major consideration for a building, the window can be used in any climate.

10/01756 Gamma-rays shielding properties of xPbO:$(100-x)B_2O_3$ glasses system at 662 keV

Kirdsiri, K. *et al. Annals of Nuclear Energy*, 2009, 36, (9), 1360–1365.

The mass attenuation coefficients, total interaction cross-sections and effective atomic numbers of $x\mathrm{PbO}{:}(100-x)\mathrm{B_2O_3}$ (where $30 \leq x \leq 70\%$ weight) glass system have been investigated on the basis of the mixture rule. The results are good agreement with the theoretical values, calculated by WinXCom. Mass attenuation coefficients were increased with increase PbO content, due to increase effective atomic number of glass samples, which increase probability of photoelectric absorption in glass. However, Compton scattering gives dominant contribution to the total mass attenuation coefficients for studied glass samples. Their shielding properties of glass samples are also better than ordinary shielding concretes and commercial window glass which can be used with advantage as transparent in visible region. These results are indicating the potential of glasses in radiation shielding materials.

10/01757 Model-oriented cast ceramic tape seals for planar solid oxide fuel cells

Sang, S. *et al. Journal of Power Sources*, 2009, 193, (2), 723–729.

A straight capillary model is developed to estimate the mass leak rate of the cast ceramic tape seals for planar solid oxide fuel cells (SOFCs), which is further rectified with consideration of microstructure complexity including the tortuosity, cross-section variation and cross-link of leak paths. The size distribution of the leak path, effective porosity and the microstructure complexity are the main factors that influence the leak rate of the cast tape seals. According to the model, Al_2O_3 powders are selected for preparation of the seals by tape casting, and the leak rate is evaluated under various compressive stresses and gauge pressures. The results indicate that Al_2O_3 powder with D_{50} value about 2 μm and specific surface area near $5\,\mathrm{m^2\,g^{-1}}$ can be used for the cast tape seals; and the obtained leak rate can satisfy the allowable leak limit.

10/01758 Optical properties of Al mirrors under impact of deuterium plasma ions in experiments simulating ITER conditions

Bardamid, A. F. *et al. Journal of Nuclear Materials*, 2009, 393, (3), 473–480.

The ion-induced modification of aluminium alloy mirrors, under bombardment by deuterium plasma ions has been investigated as a simulation of the environment effects on in-vessel mirrors in ITER. Ellipsometry and reflectrometry have been used to characterize the mirror surface, along with several surface diagnostic techniques (XPS, Auger, SIMS). The results of multiangular- and spectro-ellipsometry were analysed using both a bare surface model, and effective medium model; the medium was composed of Al, Al_2O_3 ($Al(OD)_3$ or AlOOD), and voids. It was found that the reflectance decreases following exposure to keV-range ions, but can be restored by subsequent exposing the mirror to low-energy ions (~60 eV). Chemical processes related to an increased oxide layer are thought to be responsible for the decrease in reflectance, while the reduction of the oxide layer following low-energy D^+ exposure may lead to the return of high reflectance. By comparing the measurements with the results of modelling, a mechanism is suggested to explain the experimental data. The mechanism is based on: (1) chemical processes in a surface layer and (2) changes in the thickness and roughness of the surface layer.

10/01759 Physical properties of an alumino-silicate waste form for cesium and strontium

Kaminski, M. D. *et al. Journal of Nuclear Materials*, 2009, 392, (3), 510–518.

Nuclear fuel reprocessing will be required to sustain nuclear power as a baseload energy supplier for the world. New reprocessing schemes offer an opportunity to develop a better strategy for recycling elements in the fuel and preparing stable waste forms. Advanced strategies could create a waste stream of cesium, strontium, rubidium, and barium. Some physical properties of a waste form containing these elements sintered into bentonite clay were evaluated. The authors prepared samples loaded to 27% by mass to a density of approximately 3 g/cm^3. Sintering temperatures of up to 1000 °C did not result in volatility of cesium. Instead, the crystallinity noticeably increased in the waste form as temperatures increased from 600 to 1000 °C. Assemblages of silicates were formed. Significant water evolved at approximately 600 °C but no other gases were generated at higher temperatures.

10/01760 Sorption and desorption characteristics of a packed bed of clay–$CaCl_2$ desiccant particles

Tretiak, C. S. and Abdallah, N. B. *Solar Energy*, 2009, 83, (10), 1861–1870.

Desiccants can be used in conjunction with solar energy to provide a viable alternative to traditional air conditioning techniques. A desiccant consisting of clay and calcium chloride was developed and tested using multiple sorption and desorption cycles. During sorption, inlet air temperatures from 23 to 36 °C with corresponding relative humidities of 42–66% were tested. Additionally, superficial air velocities from 0.17 to 0.85 m/s were tested. During desorption, inlet air temperatures from 50 to 57 °C and superficial air velocities of approximately 0.30 and 0.60 m/s were tested. A regression equation was determined for the mass of water sorbed by the clay–$CaCl_2$ desiccant with a R^2 value of 0.917. The desorption data was regressed to an exponential function and significant k-values were determined. An equation for pressure drop through the desiccant was determined and compared to existing models. The desiccant was found to perform well during the repeated test cycles though small masses of desiccant were lost due to surface disintegration of the desiccant spheres.

10/01761 Transparent heat mirrors based on tungsten oxide–silver multilayer structures

Al-Kuhaili, M. F. *et al. Solar Energy*, 2009, 83, (9), 1571–1577.

Transparent heat mirrors based on tungsten oxide/silver three-layer structures were fabricated using thermal evaporation. The optical and morphological properties of the single layers were first investigated to serve as a basis for the fabrication of the heat mirrors. Only silver films with a thickness higher than 18 nm were found to be continuous. Subsequently, $WO_3/Ag/WO_3$ multilayers were deposited, where the WO_3 layers thickness was fixed at 35 nm, and the thickness of the silver layer was varied from 18 to 39 nm. The optical properties of the multilayers were measured over the visible and near infrared ranges. These multilayers exhibited the desired heat mirror behaviour, namely the transmittance was largely confined to the visible range and the reflectance was diminished in that range. The maximum visible transmittance was 88.3% at 554 nm. Increasing the thickness of the silver films resulted in a decrease of the visible transmittance, with a corresponding increase in the infrared reflectance. Optimization of these two opposing trends was evaluated using a figure of merit, from which the best performance was obtained for multilayers with a silver layer of thickness of 24 nm.

13 ALTERNATIVE ENERGY SUPPLIES

Biofuels and bioconversion energy

10/01762 A thermoeconomic analysis of biomass energy for trigeneration

Lian, Z. T. *et al. Applied Energy*, 2010, 87, (1), 84–95.

This study aims to formulate a calculation process, based on the second law of exergy, for evaluating the thermoeconomic potential of a steam-turbine plant for trigeneration. The plant employs biomass, namely, waste wood as its energy source. Four different plant configurations are presented and assessed. Their cost effectiveness is evaluated with varying economic and operating parameters, because only the fuel price and electricity price are varied. In case 1, high pressure superheated steam generated is supplied to meet the demand for process heat as well as chilled water production in an absorption chiller. In cases 2 and 3, steam is extracted at appropriate stages of the turbine and supplied to meet the demand for process heat and chilled water production in an absorption chiller. Steam generated in case 2 produces sufficient power to meet internal demands while case 3 generates excess electricity for sale back to the utility. In case 4, low pressure saturated steam is generated to meet the demand for process heat and electricity is bought from the utilities, including those used to power an electric vapour-compression chiller. For all cases, it was found that exergy destruction is most extensive in the furnace, amounting to nearly 60%. Exergy destruction in the steam drum is the next most extensive ranging from 11% to 16%. It was also observed that the overall production cost decreases with steam pressure and increases with steam temperature.

10/01763 Argentinean soy-based biodiesel: an introduction to production and impacts

Tomei, J. and Upham, P. *Energy Policy*, 2009, 37, (10), 3890–3898.

This paper explores the economic, social and environmental context, drivers and impacts of increased demand for Argentine soy-based biodiesel. It is based on extensive stakeholder interviews in Argentina, including those in government, academia and the third sector; as well as participant observation with communities in soy cultivation areas; and review of relevant academic and grey literatures. Given Argentina's history of political instability and relatively weak levels of environmental protection, there is reason to be sceptical of the likely effectiveness of biofuel sustainability certification as applied to Argentine soy. Direct contracts between feedstock producers and biodiesel retailers may be a more reliable approach to minimize adverse environmental and social impacts than certification alone.

10/01764 Biodiesel production by microalgal biotechnology

Huang, G. *et al. Applied Energy*, 2010, 87, (1), 38–46.

Biodiesel has received much attention in recent years. Although numerous reports are available on the production of biodiesel from vegetable oils of terraneous oil-plants, such as soybean, sunflower and palm oils, the production of biodiesel from microalgae is a newly emerging field. Microalgal biotechnology appears to possess high potential for biodiesel production because a significant increase in lipid content of microalgae is now possible through heterotrophic cultivation and genetic engineering approaches. This paper provides an overview of the technologies in the production of biodiesel from microalgae, including the various modes of cultivation for the production of oil-rich microalgal biomass, as well as the subsequent downstream processing for biodiesel production. The advances and prospects of using microalgal biotechnology for biodiesel production are discussed.

10/01765 Biofuels development in Sub-Saharan Africa: are the policies conducive?

Jumbe, C. B. L. *et al. Energy Policy*, 2009, 37, (11), 4980–4986.

This paper analyses national, regional and international biofuels policies and strategies to assess whether these policies promote or undermine the development of biofuels sector in Africa. Despite having a huge comparative advantage in land, labour and good climatic conditions favourable for the growing of energy crops, few countries in Sub-Saharan Africa have included biofuels strategies in their energy or national development policies. Further results show that while developed countries commit huge financial resources for research, technology development and the provision of tax-incentives to both producers and consumers, there is little government support for promoting biofuels in Africa. Although the consequences of biofuels on food supply remain uncertain, the mandatory blending of biofuels with fossil fuels by industrialized countries will create demand for land in Africa for the growing of energy crops for biofuels. This paper urgently calls upon national governments in Sub-Saharan Africa to develop appropriate strategies and regulatory frameworks to harness the potential economic opportunities from biofuels sector development, while protecting the environment and rural communities from the adverse effects of land alienation from the mainstream agriculture towards the growing of energy crops for biofuels at the expense of traditional food crops.

10/01766 Catalytic upgrading of biorefinery oil from micro-algae

Tran, N. H. *et al. Fuel*, 2010, 89, (2), 265–274.

Micro-algae are seen as one of the major future fuel sources. Culture and growth of oil rich micro-algae and catalytic process for the conversion of their crude oils or biomass is reviewed here. While there is a significant literature on growth and extraction of oil from the resultant biomass the literature on the problems of refining these oils is diverse and needs collation. It is clear that previous work has been focused on the two green algae *Botryococcus braunii* and *Chlorella protothecoides* containing terpenoid hydrocarbons and glyceryl lipids as their major crude oils, respectively, both of which will need different refinery technology for upgrading. Studies show a number of conventional catalysts in the petroleum refining industry including transition metals, zeolites, acid and base catalysts can be used with variable effect. These have been employed for cracking, hydrocracking, liquefaction, pyrolysis and transesterification processes to produce diesel, jet fuel and petrol (gasoline). However there is strong evidence that new nano-scale materials containing a high number of active sites and high surface areas may offer more potential.

10/01767 Chemical forms of ash-forming elements in woody biomass fuels

Werkelin, J. *et al. Fuel*, 2010, 89, (2), 481–493.

Advanced fuel characterization helps to predict ash fouling and slagging. Chemical fractionation analysis, i.e. sequential leaching in H_2O, $NH_4Ac(aq)$, and $HCl(aq)$, was applied to the biomass of spruce, pine, birch, and aspen. All of the Cl in the samples and most of the K, Na, and P were water-soluble; most of the Mg and Mn, and some of the Ca were leached in NH_4Ac; most of the Ca was leached in HCl; and most of the Si and S remained insoluble in the biomass. Ion Chromatography found the water-soluble Cl, P, and S present as Cl^-, PO_4^{3-}, and SO_4^{2-}, respectively, and equimolar concentrations of $C_2O_4^{2-}$ as leached Ca in the acid fraction. The biomass solids were determined for anionic groups by methylene blue sorption. The contents were lowest in the wood samples (22–118 $mmol/kg_{D.S.}$) and highest in the bark samples (130–453 $mmol/kg_{D.S.}$). The closing of the ion charge balance led to a quantitative model for the ash-forming matter: water-soluble salts (KCl, K_2HPO_4, and K_2SO_4), acid-soluble minerals (CaC_2O_4), non-soluble minerals (SiO_2), and organically associated ash-forming elements (ionically bonded Ca^{2+}, Mg^{2+}, Mn^{2+}, and K^+, and covalently bonded P and S).

10/01768 Comparative study of bio-ethanol production from mahula (*Madhuca latifolia* L.) flowers by *Saccharomyces cerevisiae* cells immobilized in agar agar and Ca-alginate matrices

Behera, S. *et al. Applied Energy*, 2010, 87, (1), 96–100.

Batch fermentation of mahula (*Madhuca latifolia* L., a tree commonly found in tropical rain forest) flowers was carried out using immobilized cells (in agar agar and calcium alginate) and free cells of *Saccharomyces cerevisiae*. The ethanol yields were 151.2, 154.5 and 149.1 g kg^{-1} flowers using immobilized (in agar agar and calcium alginate) and free cells, respectively. Cell entrapment in calcium alginate was found to be marginally superior to those in agar agar (2.2% more) as well as over free cell (3.5% more) as regard to ethanol yield from mahula flowers is concerned. Further, the immobilized cells were physiologically active at least for three cycles [150.6, 148.5 and 146.5 g kg^{-1} (agar agar) and 152.8, 151.5 and 149.5 g kg^{-1} flowers (calcium alginate) for first, second and third cycle, respectively] of ethanol fermentation without apparently lowering the productivity. Mahula flowers, a renewable, non-food-grade cheap carbohydrate substrate from non-agricultural environment such as forest can serve as an alternative to food grade sugar/starchy crops such as maize, sugarcane for bio-ethanol production.

10/01769 Effective acid-catalyzed transesterification for biodiesel production

Miao, X. *et al. Energy Conversion and Management*, 2009, 50, (10), 2680–2684.

High effective acidic transesterification catalysed by trifluoroacetic acid for biodiesel production was studied in the present research. The results showed that the oil could be converted to biodiesel directly by one-step trifluoroacetic acid catalyse process without extreme temperature and pressure conditions. The optimum process combination was 2.0 M catalyst concentration with 20:1 M ratio of methanol to oil at temperature of 120 °C. It reduced product specific gravity from an initial value of 0.965 to a value of 0.878 in about 5 h of reaction time, and the methyl ester content reached as high as 98.4%. The present procedure represents a simple and mild method for biodiesel production in short reaction time and with high conversion rate, which would offer potential for an industrial process.

10/01770 Effects of minor constituents on cold flow properties and performance of biodiesel

Dunn, R. O. *Progress in Energy and Combustion Science*, 2009, 35, (6), 481–489.

Biodiesel is an alternative fuel or extender made from renewable agricultural lipids that may be burned in a compression-ignition (diesel) engine. It is defined as the mono-alkyl esters of fatty acids derived from plant oils or animal fats. Biodiesel has many important technical advantages compared to petrodiesel including superior inherent lubricity, low toxicity, high (non-flammable) flash point and biodegradability, very low or negligible sulfur content and lower exhaust emissions of most regulated species. Biodiesel is generally produced by transesterification of the lipid with a short-chain monohydric alcohol. This process may leave behind very small (trace) concentrations of minor constituents such as saturated monoacylglycerols (MAGs) or free steryl glucosides (FStGs). These materials have high melting points and very low solubilities allowing them to form solid residues when stored during cold weather. Blending with petrodiesel exacerbates the problem. Settling solid residues were found to clog fuel filters in fuel dispensers and vehicles. In response to documented problems the biodiesel industry in the United States collaborated with the American Society of Testing and Materials (ASTM) to develop a cold soak filterability performance test that will help identify fuels that may have a propensity to clog filters if exposed to long-term storage in cold weather.

10/01771 Effects of the substrate and cell concentration on bio-hydrogen production from ground wheat by combined dark and photo-fermentation

Argun, H. *et al. International Journal of Hydrogen Energy*, 2009, 34, (15), 6181–6188.

Effects of the substrate and cell concentration on bio-hydrogen production from ground wheat solution were investigated in combined dark-light fermentations. The ratio of the dark to light bacteria concentration (D/L) was kept constant at 1/10 while the wheat powder (WP) concentration was changed between 2.5 and 20 g L^{-1} with a total cell concentration of 0.41 g L^{-1} in the first set of experiments. Cell concentration was changed between 0.5 and 5 g L^{-1} in the second set of experiments while the wheat powder concentration was constant at 5 g L^{-1} with a D/L ratio of 1/7. The highest cumulative hydrogen (135 ml) and formation rate (3.44 ml H_2 h^{-1}) were obtained with the 20 g L^{-1} wheat powder concentration. However, the highest yield (63.9 ml g^{-1} starch) was obtained with the 2.5 g L^{-1} wheat powder. In variable cell concentration experiments, the highest cumulative hydrogen (118 ml) and yield (156.8 ml H_2 g^{-1} starch) were obtained with 1.1 g L^{-1} cell concentration yielding an optimal biomass/substrate ratio of 0.22 g cells/g WP.

10/01772 Electrochemical performance of a glucose/oxygen microfluidic biofuel cell

Zebda, A. *et al. Journal of Power Sources*, 2009, 193, (2), 602–606.

A microfluidic glucose/O_2 biofuel cell, delivering electrical power, is developed based on both laminar flow and biological enzyme strategies. The device consists of a Y-shaped microfluidic channel in which fuel and oxidant streams flow laminarly in parallel at gold electrode surfaces without convective mixing. At the anode, the glucose is oxidized by the enzyme glucose oxidase whereas at the cathode, the oxygen is reduced by the enzyme laccase, in the presence of specific redox mediators. Such cell design protects the anode from interfering parasite reaction of O_2 at the anode and works with different streams of oxidant and fuel for optimal operation of the enzymes. The dependence of the flow rate on the current is evaluated in order to determine the optimum flow that would provide little to no mixing while yielding high current densities. The maximum power density delivered by the assembled biofuel cell reaches 110 μW cm^{-2} at 0.3 V with 10 mM glucose at 23 °C. This research demonstrates the feasibility of advanced microfabrication techniques to build an efficient microfluidic glucose/O_2 biofuel cell device.

10/01773 Energy value as a factor of agroforestry wood species selectivity in Akinyele and Ido local government areas of Oyo State, Nigeria

Erakhrumen, A. A. *Biomass and Bioenergy*, 2009, 33, (10), 1428–1434.

Wood usage for cooking and heating is still very relevant in most developing countries especially those of sub-Saharan Africa and many parts of Asia. Therefore, sustainable means of generating it for this and other purposes are necessary bearing in mind the influence of indigenous knowledge/users' perspective on any production method regarding success and sustenance. In conformity with this view, questionnaires were administered on 240 respondents in eight rural communities of Akinyele and Ido Local Government Areas (LGAs) of Oyo State, Nigeria, to elicit information on species that can be used as fuelwood, preferred by the respondents for incorporation into and/or retention in agroforestry plots, out of which 179 (i.e. 75% of the total number of questionnaires administered) were successfully retrieved for statistical analyses. Twelve woody species namely: *Annona senegalensis, Anogeissus leiocarpus, Bridelia ferruginea, Daniellia oliveri, Detarium microcarpum, Gardenia ternifolia, Hymenocardia acida, Lophira lanceolata, Parkia biglobosa, Terminalia avicennioides, Triplochiton scleroxylon* and *Vitellaria paradoxa* were prioritized on the basis of respondents' preference using a ranking pattern. Friedman chi-square analysis showed that there was no significant difference ($p > 0.05$) in the ranking pattern of the respondents from the two LGAs. The mean net calorific values (NCV) of the 12 species were found to be 17.71, 18.63, 18.04, 16.03, 17.67, 18.46, 19.00, 21.68, 19.63, 18.25, 14.65, and 19.47 MJ kg^{-1} respectively. The result of a two-way analysis of variance indicated a significant variation ($p > 0.05$) in NCV data for all the species pooled together but not for each species except for *D. oliveri* with a follow-up test using Fisher's Least Significant Difference. The Pearson's moment correlation analysis gave positive coefficient values ($r = 0.868$ and 0.874, $p > 0.05$) between NCV and the cumulative ranking values in Akinyele and Ido LGAs respectively. There was also a coefficient value of 0.873 ($p > 0.05$) between the cumulative ranking values in the two LGAs. In line with the outcome of this study, it was therefore recommended that native intelligence/indigenous knowledge and/or users' perspective should be part of the criteria for selecting potential fuelwood species for incorporation into and/or retention in agroforestry systems in this and other areas with similar characteristics.

10/01774 Experimental study on Egyptian biomass combustion in circulating fluidized bed

Youssef, M. A. *et al. Applied Energy*, 2009, 86, (12), 2644–2650.

This study investigates the combustion of four kinds of biomass in a circulating fluidized bed. The combustion chamber is a steel cylinder with 145 mm inner diameter and 2 m height. Tests were conducted on wheat straw, sawdust-wood, cottonseed burs, and corncobs. Excess air was varied for each fuel. Temperature, heat flux and gas emissions were measured along the combustion chamber and at the chimney inlet. Results showed that sawdust-wood produces the highest values of CO emissions (about 3000 mg/Nm^3). On the other hand, cottonseed burs produce the lowest values of CO emissions (about 250 mg/Nm^3). The SO_2 emissions were very low in all tests (less than 20 mg/Nm^3). The lowest emission value occurred at an excess air ratio (EA) of 1.24 except for cottonseed burs where it was 1.4.

10/01775 Future bio-energy potential under various natural constraints

van Vuuren, D. P. *et al. Energy Policy*, 2009, 37, (11), 4220–4230.

Potentials for bio-energy have been estimated earlier on the basis of estimates of potentially available land, excluding certain types of land use or land cover (land required for food production and forests). This study explores how such estimates may be influenced by other factors such as land degradation, water scarcity and biodiversity concerns. The analysis indicates that of the original bio-energy potential estimate of 150, 80 EJ occurs in areas classified as from mild to severe land degradation, water stress, or with high biodiversity value. Yield estimates were also found to have a significant impact on potential estimates. A further 12.5% increase in global yields would lead to an increase in bio-energy potential of about 50%. Changes in bio-energy potential are shown to have a direct impact on bio-energy use in the energy model TIMER, although the relevant factor is the bio-energy potential at different cost levels and not the overall potential.

10/01776 Location of a biomass based methanol production plant: a dynamic problem in northern Sweden

Leduc, S. *et al. Applied Energy*, 2010, 87, (1), 68–75.

Concerning production and use of biofuels, mismatch between the locations of feedstock and the biofuel consumer may lead to high transportation costs and negative environmental impact. In order to minimize these consequences, it is important to locate the production plant at an appropriate location. In this paper, a case study of the county of Norrbotten in northern Sweden is presented with the purpose to illustrate how an optimization model could be used to assess a proper location for a biomass based methanol production plant. The production of lignocellulosic based methanol via gasification has been chosen, as methanol seems to be one promising alternative to replace fossil gasoline as an automotive fuel and Norrbotten has abundant resources of woody biomass. If methanol would be produced in a stand-alone production plant in the county, the cost for transportation of the feedstock as well as the produced methanol would have great impact on the final cost depending on where the methanol plant is located. Three different production plant sizes have been considered in the study, 100, 200 and 400 MW (biomass fuel input), respectively. When assessing a proper location for this kind of plant, it is important to also consider the future motor fuel demand as well as to identify a heat sink for the residual heat. In this study, four different automotive fuel- and district heating demand scenarios have been created until the year 2025. The results show that methanol can be produced at a maximum cost of 0.48 €/l without heat sales. By selling the residual heat as district heating, the methanol production cost per litre of fuel may decrease by up to 10% when the plant is located close to an area with high annual heat demand.

10/01777 On representative sampling and reliable chemical characterization in thermal biomass conversion studies

Thy, P. *et al. Biomass and Bioenergy*, 2009, 33, (11), 1513–1519.

Careful consideration and proper execution of representative sampling and mass reduction procedures are critical for the validity and reliability of chemical analyses of highly heterogeneous biomass fuels. It is demonstrated how faulty sampling can result in apparent ash compositions that differ from the true compositions by factors of 2–3 for many major oxides. Analytical results based on non-representative samples are not representative for the specific fuel and processes being studied. Despite the general acceptance that accurate and representative compositions of biomass fuel and their derivatives are a critical prerequisite for understanding reactions and elemental fractionation during combustion and other thermal conversion processes, the biomass energy community appears largely to have ignored the critical issues surrounding representative sampling. This can have resulted in misleading or faulty conclusions and may have restricted the ability to perform reliable predictive modelling. The authors here point to effective yet simple sampling principles that should be implemented in future biomass fuel studies.

10/01778 Optimization of the transesterification reaction in biodiesel production

Ferella, F. *et al. Fuel*, 2010, 89, (1), 36–42.

In this paper response surface methodology (RSM) was used to study the transesterification reaction of rapeseed oil for biodiesel production. The three main factors that drive the conversion of triglycerides into fatty acid methyl esters (FAME) were studied according to a full factorial design at two levels. These factors were catalyst concentration (KOH), temperature and reaction time. The range investigated for each factor was selected taking into account the process of Fox Petroli SpA. Analysis of variance (ANOVA) was used to determine the significance of the factors and their interactions that primarily affect the first of the two transesterification stages. This analysis evidenced the best operating conditions of the first transesterification reaction performed at Fox's plant: KOH concentration 0.6% w/w, temperature 50 °C and reaction time 90 min with a CH_3OH to KOH ratio equal to 60. Three empirical models were derived to correlate the experimental results, suitable to predict the behaviour of triglyceride, diglyceride and monoglyceride concentration. These models showed a good agreement with the experimental results, demonstrating that this methodology may be useful for industrial process optimization.

10/01779 Potential alternatives of heat and power technology application using rice straw in Thailand

Suramaythangkoor, T. and Gheewala, S. H. *Applied Energy*, 2010, 87, (1), 128–133.

Rice straw could be used for heat and power with the current technologies available in Thailand. The cost of rice straw for power generation at 0.38–0.61 Baht/MJ_e (at rice straw price 930–1500 Baht/t) is not competitive with coal at 0.30 Baht/MJ_e but comparable with other biomass at 0.35–0.53 Baht/MJ_e. However, utilization of rice straw in industrial boilers is a more competitive and flexible option with two alternatives; (1) installing rice straw fired boilers instead of heavy oil fired or natural gas ones when selecting new boilers; and (2) fuel switching from coal to rice straw for existing boilers with cost saving of feedstock supply by 0.01 Baht/MJ_h. Based on its properties (Slagging index, $R_s = 0.04$; fouling index, $R_f = 0.24$), rice straw is not expected to have significant operating problems or different emissions compared with wheat straw and rice husk under similar operating conditions.

10/01780 Pre-treatment and ethanol fermentation potential of olive pulp at different dry matter concentrations

Haagensen, F. *et al. Biomass and Bioenergy*, 2009, 33, (11), 1643–1651.

The study investigates the pre-treatment and ethanol fermentation potential of the olive pulp, which is the semi-solid residue generated from the two-phase processing of the olives for olive oil production. Wet oxidation and enzymatic hydrolysis have been applied aiming at the enhancement of carbohydrates' bioavailability. Different concentrations of enzymes and enzymatic durations have been tested. Both wet oxidation and enzymic treatment were evaluated based on the ethanol obtained in a subsequent fermentation step by *Saccharomyces cerevisiae* and *Thermoanaerobacter mathranii*. It was found that a 4-day hydrolysis time was adequate for a satisfactory release of glucose and xylose. The combination of wet oxidation and enzymatic hydrolysis resulted in the glucose and xylose concentration increase of 138 and 444%, respectively, compared to 33 and 15% with only enzymes added. However, the highest ethanol production was obtained when only enzymic pre-treatment was applied, implying that wet oxidation is not a recommended pre-treatment process for olive pulp at the conditions tested. It was also showed that increased dry matter concentration did not have a negative effect on the release of sugars, indicating that the cellulose and xylan content of the olive pulp is relatively easily available. The results of the experiments in batch processes clearly emphasize that the simultaneous saccharification and fermentation (SSF) mode is advantageous in comparison with the separate hydrolysis and fermentation (SHF) mode concerning process contamination.

10/01781 Rice straw as a renewable energy source in India, Thailand, and the Philippines: overall potential and limitations for energy contribution and greenhouse gas mitigation

Gadde, B. *et al. Biomass and Bioenergy*, 2009, 33, (11), 1532–1546.

Rice is a widely grown crop in the South and South-East Asia that leaves substantial quantity of straw in the field. The aim of this paper is to assess the quantity of rice straw produced, estimate greenhouse gas (GHG) emissions based on its current uses, and assess its possible energy potential and related GHG emissions mitigation potential. Updated statistics on rough rice production are used in this study in combination with the literature values on straw-to-grain ratio (SGR) to quantify the amount of rice straw produced in the three countries of focus. It is estimated that 97.19, 21.86, and 10.68 Mt of rice straw residue are produced in India, Thailand, and the Philippines, respectively. In India, 23% of rice straw residue produced is surplus and is either left in the field as uncollected or to a large extent open-field burnt. About 48% of this residue produced is subjected to open-field burning in Thailand, and in the Philippines it is 95%. The GHG emissions contribution through open-field burning of rice straw in India, Thailand, and the Philippines are 0.05%, 0.18%, and 0.56%, and the mitigated GHG emissions when generated electricity is used would be 0.75%, 1.81%, and 4.31%, respectively, when compared to the total country GHG emissions.

10/01782 Spatial assessment of the bioenergy potential of forest residues in the western province of Spain, Caceres

López-Rodríguez, F. *et al. Biomass and Bioenergy*, 2009, 33, (10), 1358–1366.

The present work is mainly devoted to provide a rigorous analysis on the quantification, the mapping and the management of the bioenergy potential of forest residues from the most representative forestry species of the west-central region of Spain (Cáceres). An appropriate methodological approach for the estimate of potential biomass and potential bioenergy as well as the use of GIS for data process are both crucial for the design of thermal plants and for the accurate estimate of biomass collection and transportation costs, according to the scale economy of the plant. The total forest residues in the province of Cáceres are estimated as 463,000 t y^{-1}. The availability of such major biomass potential for energy production is strongly conditioned to the inherent difficulties during the extraction process. This way, an energy potential of 139,000 toe y^{-1} would be achieved if the above-mentioned biomass collection rate is assumed. The method to optimize the search for suitable locations for thermal plants as well as for biomass extraction/collection areas, based on the combined use of GIS and spatial analysis techniques, is also described.

10/01783 Theoretical modeling of iodine value and saponification value of biodiesel fuels from their fatty acid composition

Gopinath, A. *et al. Renewable Energy*, 2009, 34, (7), 1806–1811.

Biodiesel is an alternative fuel consisting of alkyl esters of fatty acids from vegetable oils or animal fats. The properties of biodiesel depend on the type of vegetable oil used for the transesterification process. The objective of the present work is to theoretically predict the iodine value and the saponification value of different biodiesels from their fatty acid methyl ester composition. The fatty acid ester compositions and the above values of different biodiesels were taken from the available published data. A multiple linear regression model was developed to predict the iodine value and saponification value of different biodiesels. The predicted results showed that the prediction errors were less than 3.4% compared to the available published data. The predicted values were also verified by substituting in the available published model which was developed to predict the higher heating values of biodiesel fuels from their iodine value and the saponification value. The resulting heating values of biodiesels were then compared with the published heating values and reported.

10/01784 Thermal behavior of corn fibers and corn fiber gums prepared in fiber processing to ethanol

Mészáros, E. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 85, (1–2), 11–18.

In this work, a thorough study of all solid products obtained in corn fibre processing to ethanol has been carried out with thermogravimetry/mass spectrometry (TG/MS) and pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS). The thermal behaviour of corn fibre, destarched corn fibre, various alkali pretreated fibres and corn fibre gums were compared. It has been established that no significant changes occur in the thermal behaviour of the feedstock material as a result of treatment with amylolytic enzymes. On one hand only the concentration of the alkali (NaOH or KOH) seems to be important in determining the chemical composition of the pretreated corn fibre samples. On the other hand, the composition of the corn fibre gums depends on the type and not the concentration of the alkali used in the pretreatment step. The presence of H_2O_2 degrades the structure and alters the composition of the corn fibre to a larger extent. The polymeric hemicellulose which is precipitated after pretreatment with $NaOH + H_2O_2$ contains less impurities than the corn fibre gum prepared in the absence of hydrogen peroxide. The results indicate that the applied analytical methods are suitable for studying changes in the composition of the variously treated corn fibres. The observed effects of the treatments are in good agreement with data determined with conventional analytical techniques.

10/01785 Thermodynamic analysis of a solar coffee maker

Sosa-Montemayor, F. *et al. Energy Conversion and Management*, 2009, 50, (9), 2407–2412.

This paper presents a novel solar concentrating application, a coffee brewing system using a satellite TV mini-dish concentrator coupled to a stovetop espresso coffee maker. The authors present a theoretical model for the thermal behaviour of the water in the lower chamber of the coffee maker and validate the model obtaining good agreement with the experimental results. The findings indicate that the coffee brewing system works, it takes 30–50 min to complete its task. The model and this practical experience encourage making improvements to the concentration device in order to obtain a useful solar coffee maker, using the theoretical model as a safe guide to achieve this.

Geothermal energy

10/01786 A new energy analysis tool for ground source heat pump systems

Michopoulos, A. and Kyriakis, N. *Energy and Buildings*, 2009, 41, (9), 937–941.

A new tool, suitable for energy analysis of vertical ground source heat pump systems, is presented. The tool is based on analytical equations describing the heat exchanged with the ground, developed in Matlab® environment. The time step of the simulation can be freely chosen by the user (e.g. 1, 2 h, etc.) and the calculation time required is very short. The heating and cooling loads of the building, at the afore mentioned time step, are needed as input, along with the thermophysical properties of the soil and of the ground heat exchanger, the operation characteristic curves of the system's heat pumps and the basic ground source heat exchanger dimensions. The results include the electricity consumption of the system and the heat absorbed from or rejected to the ground. The efficiency of the tool is verified through comparison with actual electricity consumption data collected from an existing large scale ground coupled heat pump installation over a 3-year period.

10/01787 Application of geothermal heat pumps in a renovated campus building

Lim, J.-H. *International Journal of Energy Research*, 2010, 34, (5), 445–453.

Geothermal heat pumps (GHPs), which are normally known as ground-source heat pumps (GSHPs), offer many advantages for heating and cooling commercial buildings because of their higher energy efficiency compared with conventional electric heat pump systems. In Korea, a recent requirement for mandatory implementation of renewable energy systems in public buildings has been enforced for buildings with a floor area exceeding 3000 m^2. While GHPs may be more costly to install initially than the regular heat pumps, they can also produce markedly lower energy bills. For this reason, GHPs are being considered as heating and cooling alternatives in the renovation of campus buildings in Korea. This study investigated the application methods of GHPs for the renovation of the campus building, and compared the energy costs of GHPs with that of conventional systems. The objective of this study was to present an operation status of GSHPs in a renovated campus building as an example. When the GHP with water storage had been operating for a whole year, the coefficient of performance (COP) for heating reached from 3.12 to 5.27 according to the leaving fluid temperature and entering fluid temperature. The COP for cooling reached from 2.86 to 5.49. In comparison results, the sum of the operating costs of the GHP system was about one third of the current heating and cooling systems.

10/01788 Chemical stimulation techniques for geothermal wells: experiments on the three-well EGS system at Soultz-sous-Forêts, France

Portier, S. *et al. Geothermics*, 2009, 38, (4), 349–359.

Rock matrix stimulation is a method of enhancing well production or injection within a broad range of challenging environments, varying from naturally fractured limestones to sandstones with complex mineralogy. A common and often successful stimulation option, matrix acidizing, utilizes acids that react and remove mineral phases restricting fluid flow. Reviewed is the technology of chemical treatments available for oil, gas and geothermal wells and the key elements and results of the chemical reservoir stimulation program at the Soultz-sous-Forêts, France, Enhanced Geothermal System Project.

10/01789 Comprehensive exergy analysis of a ground-source heat pump system for both building heating and cooling modes

Bi, Y. *et al. Applied Energy*, 2009, 86, (12), 2560–2565.

This paper presents a comprehensive exergy analysis of three circuits and whole system of a ground-source heat pump (GSHP) for both building heating and cooling modes. The purpose is to search out the key potential energy saving components. The analytical formulae of exergy loss, exergy efficiency, exergy loss ratio, exergy loss coefficient and thermodynamic perfect degree are derived, respectively. The results show that these exergy indexes should be used integratively, and in the whole system the location of maximum exergy loss ratio is the compressor, while the location of minimum exergy efficiency and thermodynamic perfect degree is the ground heat exchanger, so that the compressor and the ground heat exchanger should be primarily improved. The results also indicate that the exergy loss of a GSHP system for building heating mode is bigger than that of cooling mode, and the exergy efficiency of a whole GSHP system is obviously lower than those of its components for both building heating and cooling modes. Therefore, a comprehensive exergy analysis of a GSHP should be paid more attention to. The results may provide guidelines for the design and optimization of GSHP systems.

10/01790 Efficiency improvement for geothermal power generation to meet summer peak demand

Sohel, M. I. *et al. Energy Policy*, 2009, 37, (9), 3370–3376.

Geothermal power is an important part of New Zealand's renewable electricity supply due to its attractive cost and reliability. Modular type binary cycle plants have been imported and installed in various geothermal fields in New Zealand, with plans for further expansion. Power output of these plants deteriorates in the summer because plant efficiency depends directly on the geothermal resource and the ambient temperature. As these plants normally use air-cooled condensers, incorporating a water-augmented air-cooled system could improve the power output in summer thereby matching the peak air-conditioning demand. In this work, power generation for the Rotokawa plant was characterized using a similar plant performance and local weather. The improved performance was modelled for retrofit with a wet-cooling system. Maximum generation increase on the hottest day could be 6.8%. The average gain in power over the summer, November–February, was 1.5%, and the average gain for the whole year was 1%. With current binary unit generation capacity at the Rotokawa plant of 35 MW, investment in a water-augmented air-cooled system could provide 2 MW of peak generation on the hottest days. This investment in efficiency is found to compare favourably to other supply options such as solar PV, wind or gas.

10/01791 Exergoeconomic evaluation on the optimum heating circuit system of Simav geothermal district heating system

Arslan, O. *et al. Energy and Buildings*, 2009, 41, (12), 1325–1333.

Simav is one of the most important 15 geothermal areas in Turkey. It has several geothermal resources with the mass flow rate ranging from 35 to 72 kg/s and temperature from 88 to 148 °C. Hence, these geothermal resources are available to use for several purposes, such as electricity generation, district heating, greenhouse heating, and balneological purposes. In Simav, the 5000 residences are heated by a district heating system using these geothermal resources. Beside this, a greenhouse area of 225,000 m^2 is also heated by geothermal energy. In this study, the working conditions of the Simav geothermal district heating system have been optimized. The main characteristics of the system have been presented and the impact of the parameters of heating circuit on the system are investigated by the means of energy, exergy, and life cycle cost (LCC) concepts. As a result, the optimum heating circuit has been determined as 60/49 °C.

10/01792 Numerical simulation of ground heat and water transfer for groundwater heat pump system based on real-scale experiment

Nam, Y. and Ooka, R. *Energy and Buildings*, 2010, 42, (1), 69–75.

The groundwater heat pump (GWHP) system is an open-loop system that draws water from a well or surface water, passes it through a heat exchanger and discharges the water into an injection well or nearby river. By utilizing the relatively stable temperature of groundwater, a GWHP system can achieve a higher coefficient of performance and can save more energy than conventional air-source heat pump (ASHP) system. The performance of the system depends on the condition of groundwater, especially temperature and depth, which affect performance of the heat pump and system. For the optimization of design and operation of GWHP systems, it is necessary to develop a simulation tool which can predict groundwater and heat flow and evaluate system performance comprehensively. In this research, 3D numerical heat-water transfer simulation and experiments utilizing real-scale equipment have been conducted in order to develop the optimization method for GWHP systems. Simulation results were compared with the experimental results, and the validity of the simulation model was confirmed. Furthermore, several case studies for the optimal operation method have been conducted by calculating the coefficient of performance on various groundwater and well conditions.

10/01793 The economic and environmental optimisation of integrating ground source energy systems into buildings

Dickinson, J. *et al. Energy*, 2009, 34, (12), 2215–2222.

There are currently two main drivers for the consideration of ground source energy systems in the built environment in the UK. First, building occupiers and owners are becoming increasingly concerned at rising energy prices and second, building designers are required to reduce, due to European and national and local legislation, the operational CO_2 emissions from new and existing buildings. This paper considers the application of bivalent (dual fuel) ground source heat pump (GSHP) heating and cooling systems as a way to reduce the installation costs while also providing considerable economic and environmental savings. A case study building is used to demonstrate the importance of optimizing ground loop heat exchanger length, considering differing future energy prices and the chosen appraisal period. An incremental approach is used to consider the relative benefits of increasing the size of the GSHP. Designers can also be misled by the assumption that by sizing a GSHP system to just meet the legislative targets the most economically sized system will be installed. The optimum system shows a >60% reduction in the capital cost vs a peak-sized GSHP system whilst still providing >70% of the respective economic savings and CO_2 reduction.

10/01794 The effect of borehole inclination on fluid and ground temperature for GLHE systems

Marcotte, D. and Pasquier, P. *Geothermics*, 2009, 38, (4), 392–398.

The effect of borehole inclination on ground temperatures and the practical implications it has for the designs of ground-loop heat exchangers (GLHE) systems is studied. The authors present a general formulation allowing computation of ground temperature for any number of boreholes, each borehole having its own thermal load, dip, direction, depth (of its head) and length. It is shown with an actual design that a slight tilt of the boreholes can substantially improve the theoretical performance of the GLHE.

10/01795 Vertical-borehole ground-coupled heat pumps: a review of models and systems

Yang, H. *et al. Applied Energy*, 2010, 87, (1), 16–27.

A large number of ground-coupled heat pump (GCHP) systems have been used in residential and commercial buildings throughout the world due to the attractive advantages of high efficiency and environmental friendliness. This paper gives a detailed literature review of the research and developments of the vertical-borehole GCHP technology for applications in air-conditioning. A general introduction on the ground source heat pump system and its development is briefly presented first. Then, the most typical simulation models of the vertical ground heat exchangers currently available are summarized in detail including the heat transfer processes outside and inside the boreholes. The various design/simulation programs for vertical GCHP systems primarily based on the typical simulation models are also reviewed in this paper. Finally, the various hybrid GCHP systems for cooling or heating-dominated buildings are well described. It is found that the GCHP technology can be used both in cold and hot weather areas and the energy saving potential is significant.

Solar energy

10/01796 An inexpensive and efficient pyridine-based additive for the electrolyte of dye-sensitized solar cells

Shi, J. *et al. Journal of Power Sources*, 2009, 193, (2), 878–884.

This study reports on the synthesis and application of an inexpensive pyridine-based additive allyl isonicotinate (AIN) for the efficient dye-sensitized solar cells (DSCs). AIN can be quickly synthesized at room temperature without any solvent. The presence of AIN in the electrolyte enhances the open-circuit voltage (V_{oc}), fill factor (FF) and short-circuit photocurrent (J_{sc}), consequently improving the energy conversion efficiency (η) from 6.5% to 8.2%. The impedance experiments show that the adsorption of AIN leads to the negative shift of the conduction band edge of the dye-sensitized TiO_2 around 55 mV. The presence of AIN in the electrolyte can obviously suppress the recombination of the injected electrons, increasing the lifetime of electrons in the TiO_2. The negative shift of the conduction band edge and the suppression of the recombination of the injected electrons contribute to the higher power conversion efficiency.

10/01797 Compact monocrystalline silicon solar modules with high voltage outputs and mechanically flexible designs

Baca, A. J. *et al. Energy & Environmental Science*, 2010, 3, (2), 208–211.

This paper describes a type of compact high-voltage photovoltaic module that utilizes large collections of ultrathin (~15 μm), small (~45 μm wide, ~1 mm long) silicon solar cells was fabricated and characterized. Integration on thin sheets of plastic yielded flexible modules with per-cell efficiencies of ~8%, voltage outputs >200 V, and maximum power outputs >1.5 mW.

10/01798 Development of the high concentration III-V photovoltaic system at INER, Taiwan

Kuo, C.-T. *et al. Renewable Energy*, 2009, 34, (8), 1931–1933.

The 100 kW high concentration photovoltaic (HCPV) system has been constructed in October 2007 at the Institute of Nuclear Energy Research (INER), Taiwan. The maximum module efficiency with a geometrical concentration ratio of 476× is about 26.1% under 850 W/m^2 DNI and passive cooling conditions. The 100 kW HCPV system consists of 14 sets of pillar-stand 5 kW systems and 21 sets of roof-top 1.5 kW systems. Each 5 kW system and 1.5 kW are comprised of 40 modules and 12 modules respectively. Each module was integrated with 40 solar cells with 35% conversion efficiency each, manufactured by Spectrolab Company, the highest III-V solar cell conversion efficiency record keeper. This project is the pioneer for the establishment of one MW HCPV demonstration system in 2008.

10/01799 Direct solar water splitting cell using water, WO_3, Pt, and polymer electrolyte membrane

He, X. and Boehm, R. F. *Energy*, 2009, 34, (10), 1454–1457.

A solar water splitting cell composed of WO_3, polymer electrolyte membrane (PEM) and Pt was constructed for producing hydrogen from deionized water in sunlight. Spectral responsivity measurements under various temperatures and bias voltages were conducted for the cell using the incident photon to current efficiency (IPCE) method. For comparison, a known WO_3 photoelectrochemical (PEC) cell containing H_3PO_4 electrolyte, $WO_3/H_3PO_4/Pt$, was tested using the same test method. The $WO_3/PEM–H_2O/Pt$ cell showed better Quantum Efficiency (QE) performance compared to that obtained from the cell with the chemical electrolyte. For the first time, spectral responsivity of photo water splitting process without bias power was unveiled in the new WO_3 cell, demonstrating the self-sustained photo electrolysis capability. Bias voltage effect on solar to hydrogen (STH) conversion efficiency was dramatic in the range from 0.2 V to 1.2 V and suppressions of STH were observed when high bias voltages were applied. In addition, a strong temperature effect on the energy conversion efficiency at high bias voltage was observed in the cell containing $PEM–H_2O$, revealing that the STH at 54 °C is nearly five times that at 14 °C.

10/01800 Economic efficiency of solar hot water policy in New Zealand

Gillingham, K. *Energy Policy*, 2009, 37, (9), 3336–3347.

New Zealand has recently followed the path of several other countries in promoting solar hot water (SHW) systems in the effort to reduce greenhouse gas emissions, yet the economic efficiency of large-scale policies to encourage SHW remains a pressing question for policymakers. This paper develops an economic framework to examine policies to promote SHW in New Zealand, including the current information, training, and subsidy policy. The economic framework points to environmental, energy security, and average-cost electricity retail pricing market failures as motivation for SHW policy, with the global climate change externality the most important of these. The results indicate that domestic SHW systems are close to being financially attractive from a consumer perspective, but a more substantial subsidy policy would be necessary for SHW to appeal to a wider audience. Such a policy is far more likely to have positive net benefits than a policy of mandating SHW on all homes or all new homes in New Zealand, and could be justified on economic efficiency grounds under reasonable assumptions. However, this result reverses under an economy-wide carbon trading system that internalizes the environmental externality.

10/01801 Economic evaluation of coalbed methane production in China

Luo, D. and Dai, Y. *Energy Policy*, 2009, 37, (10), 3883–3889.

Roaring natural gas demand, energy security and environment protection concerns coupled with stringent emission reduction requirement have made China's abundant coalbed methane (CBM) resource an increasingly valuable energy source. However, not all of China's CBM resource is economic to develop under current technological condition and economic situation. In order to locate the CBM resource with economic viability to develop in China, economic evaluation of CBM production is conducted by applying net present value (NPV) method. The results indicate that more than half of CBM resource in China is economic to develop. It shows that CBM price, production rate and operating costs are the three major factors with most impact on the economic viability of the CBM development in target areas in China. The result also demonstrates that the economic limit production is roughly 1200 cubic metres per day. These economic evaluation results provide important information for both CBM companies and China government.

10/01802 Effect of insulation thickness on the productivity of basin type solar stills: an experimental verification under local climate

Khalifa, A. J. N. and Hamood, A. M. *Energy Conversion and Management*, 2009, 50, (9), 2457–2461.

To achieve a high efficiency in a solar still, heat losses from the sides and base should be minimized by adequate insulation to insure the storage of the absorbed thermal energy. The effect of insulation on the productivity of a basin type solar still is verified in this study. Solar stills with insulation thickness of 30, 60 and 100 mm are investigated and the results are compared with those obtained for a still without insulation. It was found that the insulation thickness has a significant impact on the productivity of the still up to a thickness of 60 mm. The insulation thickness could influence the productivity of the still by over 80%. A performance correlation for the effect of insulation on productivity is also developed.

10/01803 Energy and economic assessment of desiccant cooling systems coupled with single glazed air and hybrid PV/thermal solar collectors for applications in hot and humid climate

Beccali, M. *et al. Solar Energy*, 2009, 83, (10), 1828–1846.

This paper presents a detailed analysis of the energy and economic performance of desiccant cooling systems (DEC) equipped with both single glazed standard air and hybrid photovoltaic/thermal (PV/t) collectors for applications in hot and humid climates. The use of 'solar cogeneration' by means of PV/t hybrid collectors enables the simultaneous production of electricity and heat, which can be directly used by desiccant air handling units, thereby making it possible to achieve very energy savings. The present work shows the results of detailed simulations conducted for a set of desiccant cooling systems operating without any heat storage. System performance was investigated through hourly simulations for different systems and load combinations. Three configurations of DEC systems were considered: standard DEC, DEC with an integrated heat pump and DEC with an enthalpy wheel. Two kinds of building occupations were considered: office and lecture room. Moreover, three configurations of solar-assisted air-handling units (AHU) equipped with desiccant wheels were considered and compared with standard AHUs, focusing on achievable primary energy savings. The relationship between the solar collector's area and the specific primary energy consumption for different system configurations and building occupation patterns is described. For both occupation patterns, sensitivity analysis on system performance was performed for different solar collector areas. Also, this work presents an economic assessment of the systems. The cost of conserved energy and the payback time were calculated, with and without public incentives for solar cooling systems. It is worth noting that the use of photovoltaics, and thus the exploitation of related available incentives in many European countries, could positively influence the spread of solar air-cooling technologies (SAC). An outcome of this work is that SAC systems equipped with PV/t collectors are shown to have better performance in terms of primary energy saving than conventional systems fed by vapour compression chillers and coupled with PV cells. All SAC systems present good figures for primary energy consumption. The best performances are seen in systems with integrated heat pumps and small solar collector areas. The economics of these SAC systems at current equipment costs and energy prices are acceptable. They become more interesting in the case of public incentives of up to 30% of the investment cost (simple payback time from 5 to 10 years) and doubled energy prices.

10/01804 Energy management algorithm for an optimum control of a photovoltaic water pumping system

Sallem, S. *et al. Applied Energy*, 2009, 86, (12), 2671–2680.

The effectiveness of photovoltaic water pumping systems depends on the adequacy between the generated energy and the volume of pumped water. This paper presents an intelligent algorithm which makes decision on the interconnection modes and instants of photovoltaic installation components: battery, water pump and photovoltaic panel. The decision is made by fuzzy rules on the basis of the photovoltaic panel generation (PVPG) forecast during a considered day, on the load required power, and by considering the battery safety. The algorithm aims to extend operation time of the water pump by controlling a switching unit which links the system components with respect to multi-objective management criteria. The algorithm implementation demonstrates that the approach extends the pumping period for more than 5 h a day which gives a mean daily improvement of 97% of the water pumped volume.

10/01805 Evaluation of the performance of three diffuse hourly irradiation models on tilted surfaces according to the utilizability concept

Posadillo, R. and Luque, R. L. *Energy Conversion and Management*, 2009, 50, (9), 2324–2330.

Three diffuse hourly irradiation models on tilted surfaces were evaluated by making a database of hourly global and diffuse solar irradiation on a horizontal surface, as well as global solar irradiation on a tilted surface, recorded in a solar radiation station located at Córdoba University (Spain). The method for a comparison of the performance of these models was developed from a study of the 'utilizable energy' statistics, a value representing, for a specific period of time, the mean monthly radiation that exceeded a critical level of radiation. This model comparison method seemed to be suitable since it provides a way of comparing the capacity of these models to estimate, however, much energy is incident on a tilted surface above a critical radiation level. Estimated and measured values were compared using the normalized RMBE and RRMSE statistics. According to the results of the method, of the three models evaluated, one isotropic and two anisotropic, the Reindl *et al*. anisotropic model was the one giving the best results.

10/01806 Exergy analysis of integrated photovoltaic thermal solar water heater under constant flow rate and constant collection temperature modes

Tiwari, A. *et al. Applied Energy*, 2009, 86, (12), 2592–2597.

This study provides an energy analysis of an integrated photovoltaic thermal solar (IPVTS) system by considering hot water withdrawal at a constant flow rate and at constant collection temperature. Analysis is based on the basic energy balance for a hybrid flat plate collector and storage tank, respectively, in the terms of design and climatic parameters. Numerical computations have been carried out for the design and climatic parameters of the system used by Huang *et al.* It is observed that the daily overall thermal efficiency of the IPVTS system increases with increased constant flow rate and decreases with increases of constant collection temperature. It is further to be noted that the overall exergy and thermal efficiency of a IPVTS is maximum at the hot water withdrawal flow rate of 0.006 kg/s.

10/01807 Experimental and numerical investigation on thermal and electrical performance of a building integrated photovoltaic–thermal collector system

Corbin, C. D. and Zhai, Z. J. *Energy and Buildings*, 2010, 42, (1), 76–82.

An experimentally validated computational fluid dynamics (CFD) model of a novel building integrated photovoltaic–thermal (BIPV/T) collector is studied to determine the effect of active heat recovery on cell efficiency and to determine the effectiveness of the device as a solar hot water heater. Parametric analysis indicates that cell efficiency can be raised by 5.3% and that water temperatures suitable for domestic hot water use are possible. Thermal and combined (thermal plus electrical) efficiencies reach 19% and 34.9%, respectively. A new correlation is developed relating electrical efficiency to collector inlet water temperature, ambient air temperature and insolation that allows cell efficiency to be calculated directly.

10/01808 Experimental investigation of heat transfer and friction factor characteristics of thermosyphon solar water heater system fitted with spacer at the trailing edge of left–right twisted tapes

Jaisankar, S. *et al. Energy Conversion and Management*, 2009, 50, (10), 2638–2649.

Experimental investigation of heat transfer and friction factor characteristics of thermosyphon solar water heater with full length left–right twist, twist fitted with rod and spacer at the trailing edge for lengths of 100, 200 and 300 mm for twist ratio 3 and 5 has been studied. The experimental data for plain tube collector has been compared with fundamental equation within a discrepancy of ±7.41% and ±14.97% for Nusselt number and friction factor, respectively. Result shows that the Nusselt number decreases by 11% and 19% for twist fitted with rod and twist with spacer, respectively, when compared with full-length twist. Friction factor also decreases by 18% and 29% for twist fitted with rod and spacer, respectively, as compared with full-length twist. The heat enhancement in twist fitted with rod at the trailing edge is maximum when compared with twist fitted with spacer because the swirl flow is maintained throughout the length of rod.

10/01809 Fuzzy logic control of stand-alone photovoltaic system with battery storage

Lalouni, S. *et al. Journal of Power Sources*, 2009, 193, (2), 899–907.

Photovoltaic energy has nowadays an increased importance in electrical power applications, since it is considered as an essentially inexhaustible and broadly available energy resource. However, the output power provided via the photovoltaic conversion process depends on solar irradiation and temperature. Therefore, to maximize the efficiency of the photovoltaic energy system, it is necessary to track the maximum power point of the PV array. The present paper proposes a maximum power point tracker (MPPT) method, based on fuzzy logic controller (FLC), applied to a stand-alone photovoltaic system. It uses a sampling measure of the PV array power and voltage then determines an optimal increment required to have the optimal operating voltage which permits maximum power tracking. This method carries high accuracy around the optimum point when compared to the conventional one. The stand-alone photovoltaic system used in this paper includes two bi-directional DC/DC converters and a lead-acid battery bank to overcome the scare periods. One converter works as an MPP tracker, while the other regulates the batteries state of charge and compensates the power deficit to provide a continuous delivery of energy to the load. The obtained simulation results show the effectiveness of the proposed fuzzy logic controller.

10/01810 Numerical study of a passive solar still with separate condenser

Madhlopa, A. and Johnstone, C. *Renewable Energy*, 2009, 34, (7), 1668–1677.

A passive solar still with separate condenser has been modelled and its performance evaluated. The system has one basin (basin 1) in the evaporation chamber and two other basins (2 and 3) in the condenser chamber, with a glass cover over the evaporator basin and an opaque condensing cover over basin 3. Basins 1, 2 and 3 yield the first, second and third effects respectively. The top part of the condensing cover is shielded from solar radiation to keep the cover relatively cool. Water vapour from the first effect condenses under the glass cover while the remainder of it flows into the condenser, by purging and diffusion, and condenses under the liner of basin 2. The performance of the system is evaluated and compared with that of a conventional solar still under the same meteorological conditions. Results show that the distillate productivity of the present still is 62% higher than that of the conventional type. Purging is the most significant mode of vapour transfer from the evaporator into the condenser chamber. The first, second and third effects contribute 60, 22 and 18% of the total distillate yield respectively. It is also found that the productivity of the solar still with separate condenser is sensitive to the absorptance of the liner of basin 1, and the mass of water in basins 1 and 2. The mass of water in basin 3 and wind speed have marginal effect on distillate production. Other results are presented and discussed in detail.

10/01811 Optimisation of solar-optical and thermal properties of buildings incorporating solar panels, emulating traditional Chinese building style

Johnston, D. A. *Energy and Buildings*, 2010, 42, (1), 63–68.

A building-integrated solar energy system, based on the traditional Chinese building (e.g. pagoda) – buildings with roofing at intermediate levels (known as eaves) – was investigated, with regard to providing for heating and cooling demands. A number of building parameters, related to energy exchange – solar absorptivity of the exterior wall, level of glazing, etc. – were optimized to minimize demand, and the orientation and tilt of the panels were selected to provide maximum energy at the times of maximum demand. Each parameter was investigated for a range of locations, in order to identify trends, which could then be applied to other locations. In most cases, solar power was sufficient to meet the cooling demands. For a number of locations, solar power provided some, but not all, of the heating loads.

10/01812 Optimum tilt angle and orientation for solar collectors in Syria

Skeiker, K. *Energy Conversion and Management*, 2009, 50, (9), 2439–2448.

One of the important parameters that affect the performance of a solar collector is its tilt angle with the horizon. This is because of the variation of tilt angle changes the amount of solar radiation reaching the collector surface. A mathematical model was used for estimating the solar radiation on a tilted surface, and to determine the optimum tilt angle and orientation (surface azimuth angle) for the solar collector in the main Syrian zones, on a daily basis, as well as for a specific period. The optimum angle was computed by searching for the values for which the radiation on the collector surface is a maximum for a particular day or a specific period. The results reveal that changing the tilt angle 12 times in a year (i.e. using the monthly optimum tilt angle) maintains approximately the total amount of solar radiation near the maximum value that is found by changing the tilt angle daily to its optimum value. This achieves a yearly gain in solar radiation of approximately 30% more than the case of a solar collector fixed on a horizontal surface.

10/01813 Overview of the photovoltaic technology status and perspective in Spain

Salas, V. and Olias, E. *Renewable and Sustainable Energy Reviews*, 2009, 13, (5), 1049–1057.

The aim of this paper is to show the current status of photovoltaic technology and the outlook for the coming years in Spain. In this way, first it gives an account of the cumulative photovoltaic power installed, the number of installations and its distribution data. Afterwards it analyses the photovoltaic implementation by assessing the significance of major projects, such as demonstration projects and photovoltaic solar farms (which use conventional and concentration photovoltaic panels). Likewise it draws attention to photovoltaic research and development activities carried out nowadays. In addition it touches on issues such as photovoltaic industry (solar silicon, cells and modules companies), new initiatives and measures of support (focusing on feed-in tariff system). Finally it lays emphasis on prospects for the coming years.

10/01814 Parametric cost–benefit analysis for the installation of photovoltaic parks in the island of Cyprus

Poullikkas, A. *Energy Policy*, 2009, 37, (9), 3673–3680.

In this work a feasibility study is carried out in order to investigate whether the installation of large photovoltaic (PV) parks in Cyprus, in the absence of relevant feed-in tariff or other measures, is economically feasible. The study takes into account the available solar potential of the island of Cyprus as well as all available data concerning current renewable energy sources (RES) policy of the Cyprus government and the current RES electricity purchasing tariff from the electricity authority of Cyprus. In order to identify the least-cost feasible option for the installation of 1 MW PV park a parametric cost–benefit analysis is carried out by varying parameters such as PV park orientation, PV park capital investment, carbon dioxide emission trading system price, etc. For all above cases the electricity unit cost or benefit before tax, as well as after-tax cash flow, net present value, internal rate of return and payback period are calculated. The results indicate that capital expenditure of the PV park is a critical parameter for the viability of the project when no feed-in tariff is available.

10/01815 Penetration of solar power without storage

Stodola, N. and Modi, V. *Energy Policy*, 2009, 37, (11), 4730–4736.

This paper addresses the question of how much of the electricity load can be substituted by solar electricity, without leaving the solar power plant substantially idle or requiring the solar power to be stored. It uses historical sunlight and electrical load data from 32 regions of the USA to determine the photovoltaic (PV) power generation capacity that could be installed such that 'almost all' of its energy output would occur at times of high demand. Specifically, what is the maximum deployment that permits 95% of the annual output from PV to be utilized without reducing the output of the baseload plants? The results for these 32 regions are that 7.8% of the total annual electricity demand could be met by installing 59 GW of PV panels. This represents about a fourth of the present electrical energy supplied by dispatchable plants. If solar power were equally effective in the rest of the USA, nearly 200 GW of PV capacity could be put to use without any energy storage. Thus, in the near term, there is enormous room for expanding the roughly 1 GW installed base of PV power without investing in night-time energy storage. The paper also provides insight into how year-to-year variability of sunlight and demand impact the results.

10/01816 Performance analysis of a solar photovoltaic operated domestic refrigerator

Modi, A. *et al. Applied Energy*, 2009, 86, (12), 2583–2591.

This paper describes the fabrication, experimentation and simulation stages of converting a 165 l domestic electric refrigerator to a solar-powered one. A conventional domestic refrigerator was chosen for this purpose and was redesigned by adding battery bank, inverter and transformer, and powered by solar photovoltaic (SPV) panels. Various performance tests were carried out to study the performance of the system. The coefficient of performance (COP) was observed to decrease with time from morning to afternoon and a maximum COP of 2.102 was observed at 7 AM. Simulations regarding economic feasibility of the system for the climatic conditions of Jaipur city (India) were also carried out using RETScreen 4. It was observed that the system can only be economically viable with carbon trading option taken into account, and an initial subsidy or a reduction in the component costs – mainly SPV panels and battery bank.

10/01817 Profits or preferences? Assessing the adoption of residential solar thermal technologies

Mills, B. F. and Schleich, J. *Energy Policy*, 2009, 37, (10), 4145–4154.

Solar thermal technologies offer the potential to meet a substantial share of residential water and space heating needs in the EU, but current levels of adoption are low. This paper uses data from a large sample of German households to assess the effects of geographic, residence, and household characteristics on the adoption of solar thermal water and space heating technologies. In addition, the impact of solar thermal technology adoption on household energy expenditures is estimated after controlling for observed household heterogeneity in geographic, residential, and household characteristics. While evidence is found of moderate household energy expenditure savings from combined solar water and space heating systems, the findings generally confirm that low in-home energy cost savings and fixed housing stocks limit the diffusion of residential solar thermal technologies. Little evidence is found of differential adoption by distinct socio-economic groups.

10/01818 Solar home systems in Botswana – opportunities and constraints

Ketlogetswe, C. and Mothudi, T. H. *Renewable and Sustainable Energy Reviews*, 2009, 13, (6–7), 1675–1678.

Lack of access to the electricity grid forms the main challenge facing majority of developing regions particularly in rural communities. The situation is driven mostly by the absence of electricity infrastructure in most of the developing countries particularly in rural communities. A number of developing countries are now encouraging the use of solar home systems in isolated areas. Botswana is not immune to this trend. Consequently, available evidence puts the overall contribution of solar energy to primary energy supply in Botswana to less than 1%. A plethora of factors are responsible for inhibiting rapid development of solar home systems in isolated areas in Botswana. Some major impediments often cited as causing low use of solar home systems by rural communities in Botswana include, among others, the following: (i) low-income status of most rural inhabitants, and (ii) migration of house-owners from village status to lands, or cattle posts. This paper, therefore, analyses factors that impede the rapid development of photovoltaics power generation systems in rural environments in Botswana. The analysis is based on photovoltaic power generation pilot project which was carried out in three villages in Botswana, namely Kudumatse, Lorolwana and Motlhabaneng.

10/01819 Solar lanterns for domestic lighting in India: viability of central charging station model

Chaurey, A. and Kandpal, T. C. *Energy Policy*, 2009, 37, (11), 4910–4918.

About 68 million households in India rely on kerosene as a fuel for domestic lighting. Kerosene-based lighting devices, not only for poor quality of light, but also for the risks of indoor air pollution and fire hazards, etc. are not a desired option for domestic lighting purposes. Solar lantern is a better alternative in terms of its quality of illumination, durability and versatility of use. The dissemination model for solar lantern in India has so far been based on cash sales with or without the incentive of capital subsidy. This paper analyses several dissemination models including rental and fee-for-service based on centralized solar charging station concept for CFL- and LED-based designs of solar lanterns available in India. The basis of comparison is the acceptable daily costs or rental to the user as well as to the owner of the charging station. Further, the paper studies the impact of likely escalation in kerosene price on the acceptable daily rental and estimates the amount of subsidy required to make the charging station model viable for disseminating solar lanterns among rural households.

Wind energy

10/01820 Analysis and inter-comparison of energy yield of wind turbines in Pakistan using detailed hourly and per minute recorded data sets

Makkawi, A. *et al. Energy Conversion and Management*, 2009, 50, (9), 2340–2350.

Within Pakistan, the ease of availability of hydrocarbon gas reserves in Balochistan had the effect of delaying the work on renewable energy feasibility and the installation of appropriate pilot projects. However, with a clear signs of depletion of fossil fuels the present government has initiated a major programme of wind speed measurement and installation of large wind farms at selected locations. The key force behind the present resurgence of renewable energy activity within Pakistan is the creation of the Alternative Energy Development Board (AEDB), established by the government of Pakistan in 2003. Under the aegis of AEDB wind speed data have been measured over a period of 4 years at a minute's frequency for southern Pakistan at Gharo. The period of measurement was May 2002 to June 2006. The study explores the potential for using hourly as opposed to minute-by-minute data for the design of wind energy systems, the former set being much more widely available for a larger number of locations within the developing world. This work has therefore centred on finding the difference in the wind energy production by using: (1) a measured long-term, minute-by-minute data, and comparing this with (2) a concurrent hourly data set. Furthermore, a comparison of the cumulative frequency of wind speed from the latter data sets has also been carried out. It was found that the difference between the annual energy outputs from the latter two data sets was in close agreement with only a percent difference. The two cumulative frequency functions were also found to be closely related. These results may be of use for locations close to the equatorial belt where the wind regime is noted for its stable and seasonal character.

10/01821 Analysis of impacts of wind integration in the Tamil Nadu grid

George, M. and Banerjee, R. *Energy Policy*, 2009, 37, (9), 3693–3700.

As the share of wind in power systems increases, it is important to assess the impact on the grid. This paper combines analysis of load and generation characteristics, generation adequacy and base and peak load variations to assess the future role of wind generation. A simulation of Tamil Nadu in India, with a high penetration of wind power (27% by installed capacity), shows a capacity credit of 22% of the installed wind capacity. For seasonal wind regimes like India, neither the capacity factor, nor the capacity credit reflects the monthly variation in the wind generation. A new approach based on the annual load duration curve has been proposed for generation expansion planning with higher penetration of wind. The potential savings in base and peak capacity required with increasing wind power have been quantified. A future scenario for Tamil Nadu for 2021 has been illustrated. It was found that 5500 MW of wind power can save

3200 MU of peak energy required or an average peak capacity of 2400 and 1100 MW of base capacity. This analysis would be useful to assess the future impacts of increasing wind capacity in grids.

10/01822 Application of design space methodology for optimum sizing of wind–battery systems

Roy, A. *et al. Applied Energy*, 2009, 86, (12), 2690–2703.
A methodology for optimum sizing of different components (i.e. rotor diameter, electrical generator rating, and battery capacity) of a standalone wind–battery system is proposed in this paper. On the basis of time series simulation of the system performance along with different design constraints, the entire set of feasible design options, also known as the design space, has been identified on a rotor diameter vs rated power diagram. The design space of a standalone wind–battery system identifies the entire envelope within which a feasible system may be designed. The optimum configuration of the standalone system is identified on the basis of minimum cost of energy (US$/kWh). It is observed that the cost of energy is sensitive to the magnitude of average demand and the wind regime. Sensitivity of the capital cost on the minimum cost of energy is also studied.

10/01823 Application of wavelets and Prony method for disturbance detection in fixed speed wind farms

Lobos, L. *et al. International Journal of Electrical Power & Energy Systems*, 2009, 31, (9), 429–436.
Voltage dips and transients are the most commonly encountered power quality disturbances in wind farms. Signal parameters estimation is an important prerequisite for power quality enhancement and for improving the fault-ride capability of wind farms and consequently, the voltage stability of the whole network. This paper examines the application of advanced signal processing methodologies such as the Prony method and wavelets for disturbance detection in wind farms. Both methodologies have been effectively tested with different disturbances simulated in a dynamic power network with a large amount of wind energy and with data signals measured at wind turbine terminals.

10/01824 Challenges of wind farms connection to future power systems in Taiwan

Lin, C.-J. *et al. Renewable Energy*, 2009, 34, (8), 1926–1930.
This paper presents the potential challenges of integrating wind farms into the future power systems in Taiwan. It first describes the developments of wind power in Taiwan and the basic criteria and general practices of connecting renewable energy resources to transmission and distribution systems at Taiwan Power Company. The paper then discusses current and future developments of power systems and wind farms in Taiwan and the possible system integrations of these potential wind farms. Finally, it identifies the major general and specific challenges of wind farm integration to the future power systems in Taiwan and concludes with suggested approaches to meet these challenges.

10/01825 Development of a tree-shaped wind power system using piezoelectric materials

Oh, S. J. *et al. International Journal of Energy Research*, 2010, 34, (5), 431–437.
A tree-shaped wind power system using piezoelectric materials was designed to produce power with any wind strong enough to cause any bending in the energy-converting elements, i.e. piezoelectric materials. Two different kinds of piezoelectric materials were used in this study to produce power by scavenging energy from the wind. The soft flexible one was used to make the leaf element, whereas the hard one was applied to the trunk portion of the tree requiring stronger winds to generate any power. Although small, each leaf played the role of a power producer as currents continuously trickled down to a storage battery installed at the bottom of the system. The test results demonstrated the possibility of generating appreciable amounts of energy depending on the piezoelectric materials applied, A more sophisticated control circuit might also be useful to enhance the system performance considered in this analysis.

10/01826 Distributed small-scale wind in New Zealand: advantages, barriers and policy support instruments

Barry, M. and Chapman, R. *Energy Policy*, 2009, 37, (9), 3358–3369.
Wind energy in New Zealand is commercially viable in many cases, yet opportunities for its exploitation are far from fully utilized. Many communities are showing resistance to wind farm developments, since large wind farms are often seen as intrusive. Building wind farms on a small scale may be a useful way of overcoming this problem. This study examines the pattern of recent wind industry development in New Zealand. It is argued that two key characteristics have emerged that are limiting the potential development of the industry: a trend towards large scale, leading to increased local opposition; and a small number of investors. Research methods include a review of international and local literature, and a rural mail survey questionnaire, with 338 respondents. The authors provide survey evidence that small wind farms, and community ownership of them, may be attractive to local communities, and that this point of advantage is helpful for the rapid expansion of wind generation in New Zealand.

10/01827 Evaluation of electricity generation and energy cost of wind energy conversion systems (WECSs) in Central Turkey

Gökçek, M. and Genç, M. S. *Applied Energy*, 2009, 86, (12), 2731–2739.
The negative effects of non-renewable fossil fuels have forced scientists to draw attention to clean energy sources which are both environmentally more suitable and renewable. Although Turkey enjoys fairly high wind energy potential, an investigation and exploitation of this source is still below the desired level. In this study which is a preliminary study on wind energy cost in Central Anatolian-Turkey, the wind energy production using time-series approach and the economic evaluation of various wind energy conversion systems (WECSs) enjoying the 2.5, 5, 10, 20, 30, 50, 100 and 150 kW rated power size using the levelized cost of electricity (LCOE) method for the seven different locations in Central Turkey were estimated. In addition, effects of escalation ratio of operation and maintenance cost and annual mean speed on LCOE are taken into account. The wind speed data for a period between 2000 and 2006 years were taken from Turkish State Meteorological Service. According to the result of the calculations, it is shown that the WECS of capacity 150 kW produce the energy output 120,978 kWh per year in the Case-A (Pinarbasi) for hub height 30 m and also the LCOE varies in the range of 0.29–30.0 $/kWh for all WECS considered.

10/01828 Exploring the potential of wind energy for a coastal state

Yue, C.-D. and Yang, M.-H. *Energy Policy*, 2009, 37, (10), 3925–3940.
Adequate recognition of the wind energy potential of coastal states may have far-reaching effects on the development of the energy systems of these countries. This study evaluates wind energy resources in Taiwan with the aid of a geographic information system (GIS), which allows local potentials and restrictions such as climate conditions, land uses, and ecological environments to be considered. The findings unveiled in this study suggest a significant role for offshore wind energy resources, which may constitute between 94% and 98% of overall wind resources in Taiwan. Total power yield from wind energy could reach between 150 and 165 TWh, which would have, respectively, accounted for between 62% and 68% of Taiwan's total power generation of 243 TWh in 2007. Based on the Taiwan's current emission factor of electricity, wind energy has the potential to reduce CO_2 emissions by between 94 and 102 million tons per year in Taiwan, which is, respectively, equivalent to 28% and 31% of the national net equivalent CO_2 emissions released in 2002. However, the challenge of managing the variability of wind power has to be addressed before the considerable contribution of wind energy to domestic energy supply and CO_2 reduction can be realized.

10/01829 Innovation and the price of wind energy in the US

Berry, D. *Energy Policy*, 2009, 37, (11), 4493–4499.
In the last 10 years, the wind energy industry has experienced many innovations resulting in wider deployment of wind energy, larger wind energy projects, larger wind turbines, and greater capacity factors. Using regression analysis, this paper examines the effects of technological improvements and other factors on the price of wind energy charged under long-term contracts in the United States. For wind energy projects completed during the period 1999–2006, higher capacity factors and larger wind farms contributed to reductions in wind energy contract prices paid by regulated investor owned utilities in 2007. However, this effect was offset by rising construction costs. Turbine size (in MW) shows no clear relationship to contract prices, possibly because there may be opposing factors tending to decrease costs as turbine size increases and tending to increase costs as turbine size increases. Wind energy is generally a low-cost resource that is competitive with natural gas-fired power generation.

10/01830 Offshore wind power in the US: regulatory issues and models for regulation

Snyder, B. and Kaiser, M. J. *Energy Policy*, 2009, 37, (11), 4442–4453.
The first offshore wind farm became operational in 1991 in Vindeby, Denmark. By 2008, large offshore wind farms had been built in Denmark, the UK, the Netherlands, Ireland, and Sweden with a total capacity of 1200 MW. Offshore wind farms have the potential to generate a significant fraction of US electrical consumption, but the US currently lacks offshore wind farms and is still developing a regulatory system. At the state level only Texas has a leasing system for offshore wind. Since all offshore land is the property of the state and cannot be legally developed without a lease from the government, these absences have stalled development. This study reviews and compares regulatory and leasing systems developed in Europe and the USA to inform a discussion of the major issues associated with the development of an offshore leasing and regulatory system. The authors focus on the

tradeoffs between encouraging a sustainable energy source and ensuring environmental protection and public compensation. It is concluded that there are likely multiple effective methods of regulation.

10/01831 Pathways to commercial wind power in the US, Europe and Japan: the role of demonstration projects and field trials in the innovation process

Harborne, P. and Hendry, C. *Energy Policy*, 2009, 37, (9), 3580–3595.
A growing, but little understood area of government involvement in promoting renewable energy, is the use of demonstration projects and field trials (DTs) as a policy tool. This paper explores the historical role of DTs in the commercialization of wind turbines. The authors review information from government, academic and industry sources, together with the newly created Cass Wind DT database, and consider the context, objectives, participants and nature of wind DTs in the EU, USA and Japan. Overall, it is difficult to identify the benefits of wind DTs for many of the key actors. Government funding of DTs does not appear to be shaped by coherent or targeted strategic objectives – indeed governments use DTs differently despite similar stated objectives. A common theme has been the involvement of many stakeholders, with local authorities, utilities and operators taking the lead rather than manufacturers. Wind DTs appear to have neither enabled participating manufacturers to become significant global suppliers – with a few exceptions driven by additional financial and legislative support from national governments-nor to have established a dominant design. The major benefit of wind DTs appears to have been ‘learning by using’ for utilities and wind farm operators, reducing operational costs.

10/01832 Probabilistic load flow with wind production uncertainty using cumulants and Cornish–Fisher expansion

Usaola, J. *International Journal of Electrical Power & Energy Systems*, 2009, 31, (9), 474–481.
This paper proposes a method for probabilistic load flow in networks with wind generation, where the uncertainty of the production is non-Gaussian. The method is based on the properties of the cumulants of the probability density functions (PDF) and the Cornish–Fisher expansion, which is more suitable for non-Gaussian PDF than other approaches, such as Gram–Charlier series. The paper includes examples and comparisons between different methods proposed in literature.

10/01833 Public perceptions of wind energy developments: case studies from New Zealand

Graham, J. B. *et al. Energy Policy*, 2009, 37, (9), 3348–3357.
Although the public generally hold positive attitudes towards wind energy, proposals for the construction of new wind farms are often met with strong resistance. In New Zealand, where the government has recently introduced ambitious policy targets for renewable energy generation, negative perceptions of wind farms are increasingly evident and have the potential to prevent the achievement of these targets. This research sets out to examine what influences social resistance to wind farms in New Zealand. Drawing from public submissions on three wind farm proposals, a framework developed by Devine-Wright was used as the basis for identification of factors affecting public perceptions of wind farms. The research found firstly that there was no apparent relationship between the proximity of submitters to a proposed wind farm and their likelihood of having a negative perception of the proposal. A wide range of factors written in submissions appeared to have affected the submitter’s decision to support or oppose the wind farm proposal. Some of these were consistent with Devine-Wright’s findings, but 10 further factors were added to the framework to adequately cover the aspects raised in submissions. The findings have implications for the achievement of New Zealand’s energy policy aspirations.

10/01834 Reflections on integrating operation and maintenance activities of offshore wind farms and mariculture

Michler-Cieluch, T. *et al. Ocean & Coastal Management*, 2009, 52, (1), 57–68.
Offshore waters are in a process of transition, revealing diverse and heterogenic interests in marine resources. This increasing complexity leads to limits in developing and managing the different and often spatially overlapping maritime activities independently of one another. On a showcase basis ways and manners as well as the preconditions of an offshore co-management approach are discussed for the fledgling actor groups offshore wind farmers and mariculturists. Both groups may benefit through the integration of operation and maintenance (O&M) activities. Their resources in terms of offers, needs and constraints characteristics and thereof deduced potentialities for interaction is a prerequisite for initiating a co-management process. This process is more likely to develop and succeed if an interface management that acts as a moderator, disclosing the interests of the actor groups and offering possibilities for concerted action, guides it. It is concluded that such an institutional arrangement may in the long term contribute to a sound methodological tool for a co-management approach between different offshore maritime sectors.

10/01835 Renewable energy sources (RES) projects and their barriers on a regional scale: the case study of wind parks in the Dodecanese islands, Greece

Oikonomou, E. K. *et al. Energy Policy*, 2009, 37, (11), 4874–4883.
The increasing energy challenges faced, in particular, by isolated communities, such as insular communities, call for an integrated, flexible and easy-to-apply methodology aiming at providing a list of renewable energy sources) (RES) projects capable to reduce green house gas (GHG) emissions, satisfy future energy forecasts and reach the objectives of international/national energy directives and obligations, as, for example, the ones set by the Kyoto Protocol by 2010. The EU project EMERGENCE 2010 developed such a methodology that is implemented here in the case study of wind parks in the Dodecanese islands in Greece. The results obtained consist of a final list of financially viable RES wind projects, for which various barriers have been previously identified and assessed. The additional advantages of the proposed methodology is that besides providing as an end result a comprehensive list of RES projects adopted to specific criteria and regional priorities, it also allows space for involving – from early stages – the local community and stakeholders in the decision-making process (participatory planning); in this way, the EMERGENCE 2010 methodology may assist towards the RES promotion and public acceptance, the profitability of RES investments and the regional sustainable development.

10/01836 Robust filtering for the characterization of wind turbines: improving its operation and maintenance

Sainz, E. *et al. Energy Conversion and Management*, 2009, 50, (9), 2136–2147.
Characterization of the wind turbine power curve in relation to the wind characteristics recorded in real scenarios is a problem that must be solved in order to optimize the operation and maintenance of a wind farm. To fit the models some data are required and the quality of the data must be assured. It is well known that real measurements are prone to incorrect data, so the application of automatic filtering techniques is essential to deal with this problem. In this study, a robust statistical technique has been adapted in order to filter the raw data taken from a real wind farms in Spain. Different models to consider the non-linear nature of the power curve in function of the wind speed and direction, and taking into account air temperature and pressure have been considered and tested. The results obtained are good and the proposed method has shown a very good robustness for rejecting incorrect data, in comparison with classical criteria for data elimination. Analysing the presented models, the authors have observed that the exponential model with direction factors is the more complete one, since it considers both the wind speed and direction in a continuous way. It gives good results but sometimes it is too exigent and it eliminates more data than required. A good alternative is the binned linear robust adjustment which gives a good filtering when there are enough data for the different sectors and bines. It is less exigent than the exponential one at high speeds, where there are few data. Both models work properly at low wind speeds, when the amount of measurements is high. The proposed techniques eliminate the need to perform various filtering steps usually done manually to reject outliers, reducing the time and costs required for the process in a great factor. The automatic and robust data processing presented also allows automatic systems to evaluate the unavailability and deviations of the efficiency of installed wind power turbines.

10/01837 Roof-top wind turbines for microgeneration in urban houses in New Zealand

Mithraratne, N. *Energy and Buildings*, 2009, 41, (10), 1013–1018.
Microgeneration using roof-top wind turbines is at present not common in New Zealand. It is, however, being trialled by the electricity network company, Vector, in a range of urban locations. Limitations of size mean roof-top wind turbines may not satisfy the total energy requirement of New Zealand houses. Ensuring structural stability and complying with stringent noise standards in New Zealand are further issues. In addition, roof-top turbines may be inefficient in terms of net energy and carbon emissions, performance indicators that are fundamental for the adoption of this technology. This paper considers the feasibility of using roof-top wind turbines in urban houses in New Zealand and, using life cycle assessment, evaluates the net energy and carbon emissions associated with their use. The results indicate that the electricity-generating potential of centralized wind farms in New Zealand using large turbines is 11.3–7 times the generating potential of roof-top turbines mounted on urban houses. In spite of this the roof-top turbines that are currently being trialled, could have the potential to reduce the energy and carbon intensity of New Zealand electricity by 81% and 26%, respectively.

10/01838 The effects of improvement of the main shaft on the operating conditions of the Agnew turbine

Yassi, Y. *Energy Conversion and Management*, 2009, 50, (10), 2486–2494.

Agnew turbine is a 45° axial flow Kaplan type micro hydro. The turbine was designed by an ex-lecturer of the University of Glasgow, to operate without guide vanes. Later due to a joint research program between the Iranian Research Organization for Science and Technology (IROST) and the University of Glasgow it was developed to operate under low head and limited flow potentials in Iran. The original design of the main shaft of the turbine was supported by a bearing housing consisting of three bearings outside the main casing, leaving the rest of the shaft, hub and the runner without any supports inside the turbine. Later a suitable support near the runner and inside the casing was designed and installed. Standard turbine tests showed considerable improvements in operating characteristics of the turbine due to these design modifications. This paper presents details of these improvements and the related outcomes.

10/01839 The offshore trend: structural changes in the wind power sector

Markard, J. and Petersen, R. *Energy Policy*, 2009, 37, (9), 3545–3556.

In recent years, the wind power sector has begun to move offshore, i.e. to use space and good wind speeds on the open sea for large-scale electricity generation. Offshore wind power, however, is not just technologically challenging but also a capital intensive and risky business that requires particular financial and organizational resources not all potential investors might have. The authors therefore address the question, what impact offshore wind power may have on ownership and organizational structures in the wind power sector. Onshore and offshore wind park ownership is compared in Denmark, the UK and Germany. The analysis shows that offshore wind power in all three countries is dominated by large firms, many of which are from the electricity sector. In Denmark and the UK, also investors from the gas and oil industry play an important role in the offshore wind business. This development represents a major shift for countries such as Germany and Denmark, in which the wind power sector has grown and matured on the basis of investments by individuals, farmers, cooperatives and independent project developers. The structural changes by which offshore wind power is accompanied have consequences for turbine manufacturers, project developers, investors, associations and policy makers in the field.

10/01840 Wind to power a new city in Oman

Albadi, M. H. *et al. Energy*, 2009, 34, (10), 1579–1586.

This paper proposes the use of wind power as a source of electricity in a new city being developed in the Duqm area of Oman. Recent wind speed measurements taken at the Duqm metrological station are analysed to obtain the annual and monthly wind probability distribution profiles represented by Weibull parameters. The monthly average mean wind speed ranges between 2.93 m/s in February and 9.76 m/s in July, with an annual average of 5.33 m/s. A techno-economic evaluation of a wind power project is presented to illustrate the project's viability. Given Duqm's wind profile and the power curve characteristics of a V90–1.8 turbine, an annual capacity factor of 0.36 is expected. For the base-case assumptions, the cost of electricity is about $0.05 and $0.08 per kWh for discount rates of 5% and 10%, respectively. These values are higher than that of the existing generation system, due to the subsidized prices of domestically available natural gas. However, given high international natural gas prices, the country's long-term LNG export obligations, and the expansion of natural gas-based industries, investments in wind power in Duqm can be justified. A feed-in tariff and capital cost allowance policies are recommended to facilitate investments in this sector.

Others, including economics

10/01841 A novel hybrid (wind–photovoltaic) system sizing procedure

Hocaoğlu, F. O. *et al. Solar Energy*, 2009, 83, (11), 2019–2028.

Wind–photovoltaic hybrid system (WPHS) utilization is becoming popular due to increasing energy costs and decreasing prices of turbines and photovoltaic (PV) panels. However, prior to construction of a renewable generation station, it is necessary to determine the optimum number of PV panels and wind turbines for minimal cost during continuity of generated energy to meet the desired consumption. In fact, the traditional sizing procedures find optimum number of the PV modules and wind turbines subject to minimum cost. However, the optimum battery capacity is either not taken into account, or it is found by a full search between all probable solution spaces which requires extensive computation. In this study, a novel description of the production/consumption phenomenon is proposed, and a new sizing procedure is developed. Using this procedure, optimum battery capacity, together with optimum number of PV modules and wind turbines subject to minimum cost can be obtained with good accuracy.

10/01842 A quadratic helix approach to evaluate the Turkish renewable energies

Celiktas, M. S. and Kocar, G. *Energy Policy*, 2009, 37, (11), 4959–4965.

The first renewable energy law concerning the 'Use of Renewable Energy Resources for the Generation of Electrical Energy' was adopted from European Union regulations on 18 May 2005 in Turkey. The purpose of the law is to expand the utilization of renewable energy resources for generating electricity. Renewables are defined in the law as generation facilities based on wind, solar, geothermal, biomass, biogas, wave, current and tidal energy resources, hydrogen energy and hydroelectric generation facilities. The aim of the study was to use strengths, weaknesses, opportunities and threats (SWOT) analysis to identify Turkish renewable energy market strategy and perspective by focusing on four different concepts: policy, market, technology and the social dimension. Different information gathering strategies have been applied such as monitoring of all statements and press releases published in the newspapers by all Turkish renewable energy parties starting from the launch of the law, articles presented in the events between 2000 and 2008 and face-to-face interviews. The results demonstrated the importance of technology development and knowledge creation for gaining competitiveness on the global arena and the need for a systematic approach for transforming the created know-how into economic and social benefits.

10/01843 A wind–PV-battery hybrid power system at Sitakunda in Bangladesh

Nandi, S. K. and Ghosh, H. R. *Energy Policy*, 2009, 37, (9), 3659–3664.

The measured wind data of Local Government Engineering Department (LGED) for 2006 at 30 m height shows a good prospect for wind energy extraction at the site. For a few months and hours the speed is below the cut in speeds of the available turbines in the market. The predicted solar radiation data from directly related measured cloud cover and sunshine duration data of Bangladesh Meteorological Department (BMD) for 1992–2003 indicates that a reliable power system can be developed over the year if the solar energy technology is merged with the wind energy technologies for this site. This research work has studied on optimization of a wind–photovoltaic-battery hybrid system and its performance for a typical community load. The assessment shows that least cost of energy (COE) is about US$0.363/kWh for a community using 169 kWh/day with 61 kW peak and having minimum amount of access or unused energy. Moreover, compared to the existing fossil fuel-based electricity supply, such an environment friendly system can mitigate about 25 t CO_2/yr. The analysis also indicates that wind–PV-battery is economically viable as a replacement for conventional grid energy supply for a community at a minimum distance of about 17 km from the grid.

10/01844 An innovation management approach for renewable energy deployment – the case of solar photovoltaic (PV) technology

Shum, K. L. and Watanabe, C. *Energy Policy*, 2009, 37, (9), 3535–3544.

The purpose of this paper is to present an innovation perspective on the renewable energy deployment process by introducing the innovation value-added chain (IVC) framework. The analytical objective of IVC is to evaluate the impact of a new innovation on the various stakeholders and players in the development and deployment processes. A deployment or innovation strategy that causes minimal disruption, enhances existing competencies, or expedites new learning by the players has a higher chance to succeed. The authors draw upon two sets of system integration costs data for grid-connected distributed photovoltaic (PV) systems in Japan and the USA and demonstrate conspicuously different dynamic learning behaviours. These two deployment models can be understood in terms of how the IVCs are organized and how PV system integration projects are performed in the field. In addition, IVC-based findings can inform the targeted application of conventional financial subsidies for learning investment not only at the PV system level, but also at the (localized) system integration level. This would involve other stakeholders, thus suggesting new energy policy space. The authors highlight some future research directions using the IVC framework.

10/01845 Analysis of transport costs for energy crops for use in biomass pyrolysis plant networks

Rogers, J. G. *et al. Biomass and Bioenergy*, 2009, 33, (10), 1367–1375.

Fast pyrolysis of biomass produces a liquid bio-oil that can be used for electricity generation. Bio-oil can be stored and transported so it is possible to decouple the pyrolysis process from the generation process. This allows each process to be separately optimized. It is necessary to have an understanding of the transport costs involved in order to carry out techno-economic assessments of combinations of remote pyrolysis plants and generation plants. Published fixed and variable costs for freight haulage have been used to calculate the transport cost for trucks running between field stores and a pyrolysis plant. It was found that the key parameter for estimating these costs was the number of round trips a day a truck could make rather than the distance covered. This zone costing approach was used to estimate the transport costs for a range of pyrolysis plants size for willow woodchips and baled miscanthus. The possibility of saving transport costs by producing bio-oil near to the field stores and transporting the bio-oil to a central plant was investigated and it was found that this would only be cost effective for large generation plants.

10/01846 Applying environmental-behaviour concepts to renewable energy siting controversy: reflections on a longitudinal bioenergy case study

Upham, P. *Energy Policy*, 2009, 37, (11), 4273–4283.

To date, studies of energy siting controversy and of environmental psychology have barely informed one another, despite the environmental-behaviour literature potentially having considerable relevance to understanding public opposition to energy projects. This paper points towards this relevance, using the example of a longitudinal study of public objections to a 21.5 MWe bioenergy gasifier proposed for Winkleigh in Devon, England. Local opinion surveys in 2004 and 2007 showed that public opposition to the proposed gasifier remained strong but also revealed some statistically significant change and correlations of wider interest. In the context of the environmental psychology literature, the dominant model of contextualized values, intention and behaviour, as well as other psychological approaches, are found to be helpful, both for making sense of the results and for informing a psychological research agenda on public objection to new energy infrastructure.

10/01847 Asia energy mixes from socio-economic and environmental perspectives

Thavasi, V. and Ramakrishna, S. *Energy Policy*, 2009, 37, (11), 4240–4250.

Sustainable clean energy is the top social, economic, and environmental agenda of political leaders, policy makers, enlightened business executives, and civil society in Asia. Strong economic growth in Asia has caused a great demand for energy which has resulted in an enormous increase in CO_2 emissions. The association of Southeast Asian nations (ASEAN), India, China, South Korea and Japan are the most important regions in Asia as their economies have been growing steadily. These countries though heavily dependent on fossil fuels have stepped up their measures towards low-carbon society amid domestic affordability challenges and changing global mindset. This report highlights the current energy scenario in these countries and their effort towards an affordable and sustainable clean energy future. The energy policy to enhance energy security and improve environmental sustainability is also explicated in this article.

10/01848 Assessment of hydropower potential using GIS and hydrological modeling technique in Kopili River basin in Assam (India)

Kusre, B. C. *et al. Applied Energy*, 2010, 87, (1), 298–309.

A hilly watershed in Kopili River basin in Assam (India) was considered for assessment of hydropower potential using spatial tool (GIS) and hydrological model (SWAT2000). The available data related to topography, soil, land use, weather and discharge pertaining to the study watershed were used to characterize the watershed. The characterization was required for water resources hence hydropower assessment. The hydrology of the study watershed was simulated through the model. The prediction accuracy of the model was confirmed through three well known efficiency criteria, viz. coefficient of determination ($R^2 = 0.70$), Nash–Sutcliffe efficiency ($E = 0.64$) and Index of agreement ($d = 0.91$). A total of 107 sites on nine streams could be identified as potential location for hydropower generation in the study watershed using the model outputs. Distributed power availability through micro units (< 0.5 MW) has been the characteristic feature of the watershed. Estimated potential carbon emission reduction (CER) within the watershed might be up to 125 thousand t CO_2, even 50% of the potential hydropower of the 1204 sq km watershed could be implemented. The result of the study is expected to boost the initiative for hydropower generation in the region considering the limitation of fossil fuels, increasing power demand and availability of untapped water resources.

10/01849 Assessment of small hydropower (SHP) development in Turkey: laws, regulations and EU policy perspective

Kucukali, S. and Baris, K. *Energy Policy*, 2009, 37, (10), 3872–3879.

This paper aims to evaluate the development of small hydropower (SHP) in Turkey and discusses the current situation of SHP plants in terms of government policy, economical aspects and environmental impacts taking EU policy into account. The laws published in recent years in Turkey succeeded in promoting the utilization of renewable energy for electricity generation, but it is considered that those laws are not fully compatible with EU policy. After the publication of Renewable Energy Law there occurred a boost in SHP project along with hydropower development. Thus, the hydropower potential of Turkey increased 15% and the construction of hydropower plants also increased by a factor of four in 2007 as compared to 2006. Investment and operating costs are in favour of SHP development in Turkey as having the lowest costs among European countries (300–1000 €/kW as investment cost and 1 €cent/kWh as operating cost). Turkish governments have taken precautions for environmental issues resulted from renewable energy utilization but these are obviously not adequate. It is concluded that more attention must be paid on environmental issues and monitoring of the facilities must be enabled with further laws or regulations.

10/01850 Bioenergy overview for Portugal

Ferreira, S. *et al. Biomass and Bioenergy*, 2009, 33, (11), 1567–1576.

Bioenergy is seen as one of the key options to mitigate greenhouse gas emissions and substitute fossil fuels. Bioenergy is also an atypical energy source due to its diversity and inter-linkages with many other technological and policy areas. The goal of this paper is to analyse the Portuguese possibilities for bioenergy provision from biomass. The potentials of biomass, conversion technologies and legal framework are analysed and discussed. The result of this analysis shows that there are still unused potentials especially from forestry, which can contribute significantly to cover the bioenergy targets. However, the Portuguese experience with conversion technologies is limited to combustion, which is a drawback that must be solved so as to the bioenergy potential can be used. Research and development projects, as well as demonstration projects are needed in order to improve the efficiency of the technological processes. At political level, Portuguese governments have been following the policies and strategies of the European Commission in the energy sector. However, energy crops market, due to the inter-linkage with agricultural policy, seems to need some additional political impetus.

10/01851 Bioethanol development in China and the potential impacts on its agricultural economy

Qiu, H. *et al. Applied Energy*, 2010, 87, (1), 76–83.

China is now the third largest bioethanol producer in the world after the USA and Brazil. This paper aims to provide an overview of China's current bioethanol programme, its future trend, and the likely impacts on its agricultural economy in the future. The analysis shows that China has developed an ambitious long-run biofuel program with a series of financial and institutional supports. While there are several potential feedstock crops available for bioethanol production, lack of land for feedstock production is one of major constraints in China's bioethanol expansion. The results show that although China's bioethanol expansion will have little impacts on overall agricultural prices in international markets, it will have significant impacts on the prices, productions, and trade of those energy crops being used for bioethanol production in China.

10/01852 Biofuel developments in Sweden and the Netherlands: protection and socio-technical change in a long-term perspective

Ulmanen, J. H. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (6–7), 1406–1417.

This paper reviews long-term development of biofuels in Sweden and the Netherlands. In particular this paper explores the social dynamics of 'niche protection'. The Swedish and Dutch cases are analysed by means of the strategic niche management perspective extended with insights from political science. The main argument here is that the development of biofuels and the way this development is protected relies on a variety of actor strategies and (local and global) discourses. This case therefore suggests that policy making for biofuels is a complex and non-linear process that can only partly be managed by policy actors.

10/01853 Biofuels and synthetic fuels in the US and China: a review of well-to-wheel energy use and greenhouse gas emissions with the impact of land-use change

Yan, X. *et al. Energy & Environmental Science*, 2010, 3, (2), 190–197.

Alternative transportation fuels are projected to grow substantially due to energy security concerns especially in the USA and China. Moreover, some of these fuels can potentially reduce greenhouse gas emissions from the transportation sector and hence, can help to mitigate climate change. This comprehensive review considers well-to-wheel fossil fuel use and greenhouse gas emissions of biofuels and synthetic fuels in the USA and China, including emissions from land-use change. The results are carefully benchmarked to the emissions caused by crude oil-derived fuels as well as synthetic fuels from fossil feedstocks in order to estimate the potential emission reduction or increase. The review strongly suggests that biofuels and synthetic fuels can contribute to greenhouse gas mitigation in the transport sector only if appropriate feedstocks are used and emissions from land-use change are minimized.

10/01854 Biofuels securing the planet's future energy needs

Demirbas, A. *Energy Conversion and Management*, 2009, 50, (9), 2239–2249.

The biofuels include bioethanol, biobutanol, biodiesel, vegetable oils, biomethanol, pyrolysis oils, biogas, and biohydrogen. There are two global biomass-based liquid transportation fuels that might replace gasoline and diesel fuel; these are bioethanol and biodiesel. World production of biofuel was about 68 billion litres in 2007. The primary feedstocks of bioethanol are sugarcane and corn. Bioethanol is a gasoline additive/substitute. Bioethanol is by far the most widely used biofuel for transportation worldwide. About 60% of global bioethanol production comes from sugarcane and 40% from other crops. Biodiesel refers to a diesel-equivalent mono alkyl ester based oxygenated fuel. Biodiesel production using inedible vegetable oil, waste oil and grease has become more attractive recently. The economic performance of a biodiesel plant can be determined once certain factors are identified, such as plant capacity, process technology, raw material cost and chemical costs. The central policy of biofuel concerns job creation, greater efficiency in the general business environment, and protection of the environment.

10/01855 Cornerstones of a renewable energy law for emerging markets in South America

Kissel, J. M. *et al. Energy Policy*, 2009, 37, (9), 3621–3626.

Since 1990, effective support schemes for renewable energies have been introduced mainly in European countries. In this article, the authors explain which consequences different general conditions could have on the design and functioning of feed-in laws. Cornerstones for an adjusted feed-in law to the particular general conditions of emerging and developing countries in South America will be drawn, which should give support to the decision-makers for designing an attuned and well-functioning feed-in legislation.

10/01856 Economic feasibility of solar-powered led roadway lighting

Wu, M. S. *et al. Renewable Energy*, 2009, 34, (8), 1934–1938.

The optical efficacy of light emitting diode (LED) has exceeded 72 lm/W in 2006. This implies that energy can be saved about 75%, as compared to mercury lamps widely used in roadway lighting. In some remote areas where the grid power cannot reach, independent solar-powered lighting using high-power LED provides a promising solution. However, the cost of solar photovoltaic device may cause the application of solar-powered LED roadway lighting to be not economically feasible. The present study investigates the design of the solar-powered LED roadway lighting using high-power LED luminaire (100 W) and estimates the installation cost for a 10 km highway with 2 lanes. LED luminaries are installed on both side of the road with staggered arrangement. The pole distance is 30 m. The cost comparison of LED lighting using grid and solar power with the conventional mercury lamps was carried out. It shows that the installation cost is US$22 million for LED powered by grid power and US$26 million for solar-powered. The total installation cost of conventional mercury lighting is US$18 million. The excess cost of LED mainly comes from the cost of LED lamp and solar PV. But, the cost of power generation and electrical transmission line can be greatly reduced since about 75% energy was saved for LED. This permits the use of smaller copper wire and shorter line length for solar-powered system which in turn saves installation cost. The payback time for the excess investment of LED is 2.2 years for LED using grid power and 3.3 years for LED using solar power.

10/01857 Economics of wind turbine as an energy fuel saver – a case study for remote application in Oman

Malik, A. and Al-Badi, A. H. *Energy*, 2009, 34, (10), 1573–1578.

This paper presents a study carried out to investigate the economics of wind turbine as an energy fuel saver. The load and the wind data are taken from a remote agricultural research station in Oman. Presently, the station is provided with electricity from diesel-engine generating units. The annual peak load and minimum load recorded at the site is 130 kW and 28 kW respectively. The annual average wind speed at the site is 5.7 m/s. A 50-kW wind turbine is selected to demonstrate the economic feasibility of the turbine as a fuel saver. The results show that wind energy utilization is an attractive option with total specific cost of the selected wind turbine ranges between 7.4 and 8.45 cents/kWh at 7.55% discount rate comparing to diesel generation operating cost of 14.3 cents/kWh, considering the capital cost of diesel units as sunk. The simple payback period of the turbine is between 5.1 and 5.4 years and discounted payback between 6.7 and 8.0 years.

10/01858 Fuelwood: the 'other' renewable energy source for Africa?

Hiemstra-van der Horst, G. and Hovorka, A. J. *Biomass and Bioenergy*, 2009, 33, (11), 1605–1616.

In recent years, increasing concerns over rising oil prices, supply shortfalls and the environmental impacts of fossil fuel use have fed growing interest in renewable energy sources for Sub-Saharan Africa. Although traditional biofuels already enjoy widespread popularity, their use has often been actively discouraged due to the lingering influence of 'fuelwood crisis' era narratives. In particular, urban fuelwood consumption is frequently portrayed as a cause of environmental degradation leading to energy insecurity among low-income households, especially where the resource is commercialized. Such views have had significant influence among policy makers, often resulting in repressive forestry legislation. In contrast, however, a number of researchers have demonstrated that wood energy dependence is often not a significant cause of deforestation and can provide important livelihood opportunities. This article reassesses urban fuelwood sourcing and its impacts using a recent case study conducted by the authors in Maun, Botswana and results previously reported in the literature. Findings indicate that although harvesting is unregulated, its impacts are significantly mitigated by collectors' strong preferences for source sites with abundant dead wood, low competition and recognized access rights. As well, fuelwood vending is found to provide critical support to rural incomes and a key source of low-cost urban energy. As such, the benefits of fuelwood use and avoidance of negative effects will most effectively be achieved by decentralized management approaches that build on local institutions and understandings of the resource.

10/01859 Impacts of a United States' biofuel policy on New Zealand's agricultural sector

Saunders, C. *et al. Energy Policy*, 2009, 37, (9), 3448–3454.

The rise in oil prices has spurred interest in biofuels. Policies in the United States like the renewable fuel standard (RFS) have led to an expansion of ethanol production, while the New Zealand government has mandated a minimum level of biofuel sales. The research used a partial equilibrium model of international trade to quantify the price and farmgate income effects of the US RFS policy. The goal was to examine the competition between food and biofuel production and to quantify the impact of the policy on the agricultural sector in New Zealand. The RFS policy has a significant impact on corn prices, but a small effect on livestock prices and production. There thus appears to be little conflict between food and fuel uses for corn at the level of the RFS mandate. New Zealand's pasture-based livestock sector benefits from the use of corn for ethanol production: it receives better prices for its products, but does not face the same input cost increases as competitors. The results suggest that New Zealand faces an interesting decision: it could support investment in biofuels research, or benefit from the biofuels boom through the indirect impacts on demand and prices for meat and milk.

10/01860 Innovative private micro-hydro power development in Rwanda

Pigaht, M. *et al. Energy Policy*, 2009, 37, (11), 4753–4760.

Under the 'Private Sector Participation in Micro-Hydro Development Project in Rwanda', four newly registered Rwandan companies are each constructing a micro-hydro electricity plant (100–500 kW) and building a low-voltage distribution grid. These companies financed their plants through their own equity and debt with support from the PSP hydro project. This support comprised a subsidy of 30–50% of investment costs, technical and business development assistance, project monitoring and financial controlling. The experiences gained so far have important implications for similar future micro-hydro energy sector development projects and this paper puts forward three key messages: (1) institutional arrangements rather than technical quality determine the success of such projects; (2) truly sustainable rural electrification through micro-hydro development demands a high level of local participation at all levels and throughout all project phases, not just after plant commissioning; and (3) real impact and sustainability can be obtained through close collaboration of local private and financial sector firms requiring only limited external funds. In short, micro-hydro projects can and will be taken up by local investors as a business if the conditions are right. Applying these messages could result in an accelerated uptake of viable micro-hydro activities in Rwanda, and in the opinion of the authors elsewhere too.

10/01861 International renewable energy policy – between marginalization and initial approaches

Hirschl, B. *Energy Policy*, 2009, 37, (11), 4407–4416.

This article undertakes an analysis of renewable energy policy at the international level. So far, such policy efforts have been carried out in a fragmented manner across various fields and without the benefit of any specific international agreements or organizations. In the two key policy areas of energy and climate, in which one would expect to find direct approaches at the international level, there have been only marginal efforts to promote renewable energy and with little direct impact – something which at first glance is rather remarkable. Initiated in the wake of the Second World Summit on Sustainable Development, in 2002 in Johannesburg, there exists for the first time a specific policy process – set in motion by the German government – which has led to some initial 'soft' instruments and institutional forms; this multilateral process, which, although parallel and independent in its approach, is proceeding nonetheless in a consensual manner similar to the UN negotiations. At the same time, several countries have taken the lead to form an international organization for renewable energy; this is presently being developed. This article examines the various policy levels as well as the roles of the significant national and international actors on the basis of a multilevel governance approach.

10/01862 Optimal design of district heating and cooling pipe network of seawater-source heat pump

Li, X.-L. *et al. Energy and Buildings*, 2010, 42, (1), 100–104.
District heating and cooling (DHC) using a seawater-source heat pump involves large system engineering. The investments and the operational cost of a DHC pipe network are higher than a tradition system, so the authors built a least-annualized-cost global optimal mathematic model to investigate further. Furthermore, this model considers the variety of heating load and cooling load, the operational adjustment in different periods of the year. Genetic algorithm (GA) was used to obtain the optimal combinations of discrete diameters. Some operators of GA were selected to reduce the calculation time and obtain good calculation accuracy. This optimal method was used in the DHC network of the Xinghai Bay commercial district. Design optimization can avoid the hydraulic unbalance of the system, enhance the running efficiency and greatly reduce the annualized-cost comparing with the traditional design method.

10/01863 Planning of community-scale renewable energy management systems in a mixed stochastic and fuzzy environment

Cai, Y. P. *et al. Renewable Energy*, 2009, 34, (7), 1833–1847.
In this study, an interval-parameter superiority–inferiority-based two-stage programming model has been developed for supporting community-scale renewable energy management (ISITSP-CREM). This method is based on an integration of the existing interval linear programming (ILP), two-stage programming (TSP) and superiority–inferiority-based fuzzy-stochastic programming (SI-FSP). It allows uncertainties presented as both probability/possibilistic distributions and interval values to be incorporated within a general optimization framework, facilitating the reflection of multiple uncertainties and complexities during the process of renewable energy management systems planning. ISITSP-CREM can also be used for effectively addressing dynamic interrelationships between renewable energy availabilities, economic penalties and electricity-generation deficiencies within a community scale. Thus, complexities in renewable energy management systems can be systematically reflected, highly enhancing applicability of the modelling process. The developed method has then been applied to a case of long-term renewable energy management planning for three communities. Useful solutions for the planning of renewable energy management systems have been generated. Interval solutions associated with different energy availabilities and economic penalties have been obtained. They can be used for generating decision alternatives and thus help decision-makers identify desired policies under various economic and system-reliability constraints. The generated solutions can also provide desired energy resource/service allocation plans with a minimized system cost (or economic penalties), a maximized system reliability level and a maximized energy security. Tradeoffs between system costs and energy security can also be tackled. Higher costs will increase potential energy generation amount, while a desire for lower system costs will run into a risk of energy deficiency. They are helpful for supporting: (a) adjustment or justification of allocation patterns of renewable energy resources and services, (b) formulation of local policies regarding energy utilization, economic development and energy structure under various energy availabilities and policy interventions, and (c) analysis of interactions among economic cost, system reliability and energy-supply shortage.

10/01864 Portfolio management of hydropower producer via stochastic programming

Liu, H. *et al. Energy Conversion and Management*, 2009, 50, (10), 2593–2599.
This paper presents a stochastic linear programming framework for the hydropower portfolio management problem with uncertainty in market prices and inflows on medium term. The uncertainty is modelled as a scenario tree using the Monte Carlo simulation method, and the objective is to maximize the expected revenue over the entire scenario tree. The portfolio decisions of the stochastic model are formulated as a tradeoff involving different scenarios. Numerical results illustrate the impact of uncertainty on the portfolio management decisions, and indicate the significant value of stochastic solution.

10/01865 Practical aspects in solving the medium-term operation planning problem of hydrothermal power systems by using the progressive hedging method

dos Santos, M. L. L. *et al. International Journal of Electrical Power & Energy Systems*, 2009, 31, (9), 546–552.
The medium-term operation planning (MTOP) of hydrothermal systems aims to define generation targets that minimize the expected operation cost over the planning period, considering a set of constraints with respect to the power system and the generating units. Mathematically, this problem can be characterized as a linear, stochastic and large scale, which requires the application of suitable optimization tools. The purpose of this paper is to apply the progressive hedging (PH) method to solve the MTOP problem. For that, two critical aspects of the PH are addressed: the use of warm start and the choice of a suitable penalty parameter. In addition, this paper compares the performance of the PH to other popular methods, the full high-scale linear programming problem, also known as deterministic equivalent, and the nested decomposition, when solving similar problems. As a result it is shown that the PH is a competitive method to solve the MTOP problem.

10/01866 Probabilistic evaluation of reserve requirements of generating systems with renewable power sources: the Portuguese and Spanish cases

Matos, M. *et al. International Journal of Electrical Power & Energy Systems*, 2009, 31, (9), 562–569.
This paper presents an application of probabilistic methodologies to evaluate the reserve requirements of generating systems with a large penetration of renewable energy sources. The idea is to investigate the behaviour of reliability indices, including those from the well-being analysis, when the major portion of the renewable sources comes from wind power and other intermittent sources. A new simulation process to address operating reserve adequacy is introduced, and the correspondent reliability indices are observed. Case studies on the Portuguese and Spanish generating systems are presented and discussed.

10/01867 Rejecting renewables: the socio-technical impediments to renewable electricity in the United States

Sovacool, B. K. *Energy Policy*, 2009, 37, (11), 4500–4513.
If renewable power systems deliver such impressive benefits, why do they still provide only 3% of national electricity generation in the United States? As an answer, this article demonstrates that the impediments to renewable power are socio-technical, a term that encompasses the technological, social, political, regulatory, and cultural aspects of electricity supply and use. Extensive interviews of public utility commissioners, utility managers, system operators, manufacturers, researchers, business owners, and ordinary consumers reveal that it is these socio-technical barriers that often explain why wind, solar, biomass, geothermal, and hydroelectric power sources are not embraced. Utility operators reject renewable resources because they are trained to think only in terms of big, conventional power plants. Consumers practically ignore renewable power systems because they are not given accurate price signals about electricity consumption. Intentional market distortions (such as subsidies), and unintentional market distortions (such as split incentives) prevent consumers from becoming fully invested in their electricity choices. As a result, newer and cleaner technologies that may offer social and environmental benefits but are not consistent with the dominant paradigm of the electricity industry continue to face comparative rejection.

10/01868 Renewable energy consumption and income in emerging economies

Sadorsky, P. *Energy Policy*, 2009, 37, (10), 4021–4028.
Increased economic growth and demand for energy in emerging economies is creating an opportunity for these countries to increase their usage of renewable energy. This paper presents and estimates two empirical models of renewable energy consumption and income for a panel of emerging economies. Panel cointegration estimates show that increases in real per capita income have a positive and statistically significant impact on per capita renewable energy consumption. In the long term, a 1% increase in real income per capita increases the consumption of renewable energy per capita in emerging economies by approximately 3.5%. Long-term renewable energy per capita consumption price elasticity estimates are approximately equal to −0.70.

10/01869 Socio-psychological impacts of the introduction of energy technologies: change in environmental behavior of households with photovoltaic systems

Hondo, H. and Baba, K. *Applied Energy*, 2010, 87, (1), 229–235.

After installing a photovoltaic (PV) system in a house or a school, it is said that people seem to increase behaviour that shows concern for the environment such as saving electricity. Do characteristics of PV systems have any influence on the change in people's behaviour? This study attempts to discover why people's behaviour toward energy and the environment change after installing a PV system. Based on questionnaire surveys, this paper describes the results of statistical analysis concerning the changes in households that installed PV systems. The results show that in households where the family members are highly aware of their PV systems they tend to increase environmental behaviour after installing the PV system. It is also found that an increase in communication about environmental behaviour in a family tends to go hand-in-hand with the increase in environmental behaviour. The findings suggest that the installation of residential PV systems affect people's concern and norms related to energy and the environment, and consequently influences people's behaviour.

10/01870 Systems analyses and the sustainable transfer of renewable energy technologies: a focus on remote areas of Africa

Brent, A. C. and Kruger, W. J. L. *Renewable Energy*, 2009, 34, (7), 1774–1781.

Sustainable energy provision is regarded as one of the most significant challenges facing the realm of development, especially in Africa where large proportions of the population still lack access to energy services. Although there have been much efforts to address these problems with renewable energy technologies, there have also been substantial failures and problems. The Intermediate Technology Development Group (ITDG) has developed a manual that seeks to address these implementation issues. The Renewable Energy for Sustainable Rural Livelihoods workgroup has also developed such a framework, termed SURE, which is a multi-criteria decision analysis modelling tool. Both of these frameworks rely heavily on the Sustainable Livelihoods Approach and emphasize the need to rigorously analyse the subsystems where technologies are to be introduced. These two frameworks have been integrated and assessed in terms of their applicability for the South African rural renewable energy landscape through a Delphi study conducted with several experts in the energy sector. The results indicate that the integrated framework is suitable for the South African context, with additions to the ITDG and SURE frameworks suggested. Finally the paper highlights a potential concern in the South African renewable energy industry in that technology assessment methods that are utilized in practise do not incorporate the concepts of sustainability science adequately; this must be addressed through further case study research efforts.

10/01871 The rise and fall of GO trading in European renewable energy policy: the role of advocacy and policy framing

Nilsson, M. *et al. Energy Policy*, 2009, 37, (11), 4454–4462.

This paper examines policy processes surrounding the rise and fall of the proposed EU-wide policy instrument designed to help achieve the EU's renewable energy targets – the trading of guarantees of origin (GO). It discusses its origins and examines factors in the policy processes over time leading first to its development and then to its abandonment. A first analysis looks at the near-term policy-making process before and after the proposal on GO trading in January 2008, focusing on the European policy-making institutions and influences of interest groups and member state governments. It then takes a step back and looks over a longer time period at how competing policy frames have shaped the agendas underlying the debate. Results show how a strong internal market frame acted as a primary driving force in the Commission to promote the GO trading instrument. The rejection of the GO trading proposal in the Council and Parliament can be largely attributed to the lack of a strong lobby in favour of GO, the accumulated experience with and institutionalization of national RES support policies such as feed-in tariffs, and growing general political concerns for supply security, innovation and competitiveness.

10/01872 Willingness-to-pay for renewable energy: primary and discretionary choice of British households' for micro-generation technologies

Scarpa, R. and Willis, K. *Energy Economics*, 2010, 32, (1), 129–136.

This paper documents the policy context of renewable energy production in the European Union. The research adopts a choice experiment approach to investigate households' WTP for these renewable energy technologies in the UK. The micro-generation technologies comprise solar photovoltaic, micro-wind, solar thermal, heat pumps, and biomass boilers and pellet stoves. The study compares the results from conditional and mixed logit models, which estimate the distribution of utility coefficients and then derives WTP values as a ratio of the attribute coefficient to the price coefficient, with a model in which the WTP distribution is estimated directly from utility in the money space. The results suggest that whilst renewable energy adoption is significantly valued by households, this value is not sufficiently large, for the vast majority of households, to cover the higher capital costs of micro-generation energy technologies.

14 FUEL SCIENCE AND TECHNOLOGY

Fundamental science, analysis, instrumentation

10/01873 A case study in data audit and modelling methodology – Australia

Apelbaum, J. *Energy Policy*, 2009, 37, (10), 3714–3732.

The purpose of the paper is to outline a rigorous, spatially consistent and cost-effective transport planning tool that projects travel demand, energy and emissions for all modes associated with domestic and international transport. The planning tool (Aus$_{e}$Tran) is a multi-modal, multi-fuel and multi-regional macroeconomic and demographic-based computational model of the Australian transport sector that overcomes some of the gaps associated with existing strategic level transport emission models. The paper also identifies a number of key data issues that need to be resolved prior to model development with particular reference to the Australian environment. The strategic model structure endogenously derives transport demand, energy and emissions by jurisdiction, vehicle type, emission type and transport service for both freight and passenger transport. Importantly, the analytical framework delineates the national transport task, energy consumed and emissions according to region, state/territory of origin and jurisdictional protocols, provides an audit mechanism for the evaluation of the methodological framework, integrates a mathematical protocol to derive time series FFC emission factors and allows for the impact of non-registered road vehicles on transport, fuel and emissions.

10/01874 A comparative analysis for multiattribute selection among renewable energy alternatives using fuzzy axiomatic design and fuzzy analytic hierarchy process

Kahraman, C. *et al. Energy*, 2009, 34, (10), 1603–1616.

In this paper, fuzzy multicriteria decision-making methodologies are suggested for selecting among renewable energy alternatives. The first methodology is based on the AHP which allows the evaluation scores from experts to be linguistic expressions, crisp, or fuzzy numbers, while the second is based on AD principles under fuzziness which evaluates the alternatives under objective or subjective criteria with respect to the functional requirements obtained from experts. The originality of the paper comes from the fuzzy AD application to the selection of the best renewable energy alternative and the comparison with fuzzy AHP. In the application of the proposed methodologies the most appropriate renewable energy alternative is determined for Turkey.

10/01875 A decoupled power flow algorithm using particle swarm optimization technique

Acharjee, P. and Goswami, S. K. *Energy Conversion and Management*, 2009, 50, (9), 2351–2360.

A robust, non-divergent power flow method has been developed using the particle swarm optimization (PSO) technique. The decoupling properties between the power system quantities have been exploited in developing the power flow algorithm. The speed of the power flow algorithm has been improved using a simple perturbation technique. The basic power flow algorithm and the improvement scheme have been designed to retain the simplicity of the evolutionary approach. The power flow is rugged, can determine the critical loading conditions and also can handle the flexible alternating current transmission system (FACTS) devices efficiently. Test results on standard test systems show that the proposed method can find the solution when the standard power flows fail.

10/01876 A free-parameter theoretical model for describing the electron elastic scattering in water in the Geant4 toolkit

Champion, C. *et al. Radiation Physics and Chemistry*, 2009, 78, (9), 745–750.

The present work provides an accurate description of the elastic scattering process for low-energy electrons (10 eV–10 keV) in liquid water by means of a free-parameter quantum-mechanical treatment. The calculations are performed in the partial-wave formalism by means of a total interaction potential taking into account a static contribution as well as fine effects like exchange and polarization contributions. The obtained results in terms of singly differential and total cross-sections exhibit relatively good agreement with available experimental data (in gaseous water). They have been incorporated into the Geant4 toolkit, which has been recently extended with physics processes for microdosimetry applications in liquid water down to the electronvolt scale. They offer an improved alternative to the semi-empirical and to the screened Rutherford models already available in this very low-energy extension.

10/01877 A metafrontier approach for measuring an environmentally sensitive productivity growth index

Oh, D. *Energy Economics*, 2010, 32, (1), 146–157.

This paper presents an alternative environmentally sensitive productivity growth index to incorporate group heterogeneities into a conventional Malmquist–Luenberger productivity growth index. The proposed approach allows the calculation of both efficiency and technical changes, for economic agents operating under different technologies. Moreover, it also enables the computation of changes in the technological gap between regional and global frontier technologies. The proposed index is employed in measuring productivity growth and its decomposed components in 46 countries between 1993 and 2003. The main finding is that Europe has taken the lead in the world frontier technology and that Asia has attempted to move towards the frontier technology. Subsequent policy implications are provided based on some empirical studies.

10/01878 A multiobjective approach for solving cooperative *n*-person games

Maali, Y. *International Journal of Electrical Power & Energy Systems*, 2009, 31, (10), 608–610.

A linear programming model is introduced to solve cooperative games. The solution is always Pareto optimal. It is based on the idea of the core but instead of requiring rationality for all groups, a multiobjective approach is proposed including the importance weights of the players. A case study illustrates the application of this method.

10/01879 An efficient parallel computing scheme for Monte Carlo criticality calculations

Dufek, J. and Gudowski, W. *Annals of Nuclear Energy*, 2009, 36, (8), 1276–1279.

The existing parallel computing schemes for Monte Carlo criticality calculations suffer from a low efficiency when applied on many processors. A new fission matrix based scheme is suggested for efficient parallel computing. The results are derived from the fission matrix that is combined from all parallel simulations. The scheme allows for a practically ideal parallel scaling as no communication among the parallel simulations is required, and inactive cycles are not needed.

10/01880 An improved three-dimensional wavelet-based method for solving the first-order Boltzmann transport equation

Zheng, Y. *et al. Annals of Nuclear Energy*, 2009, 36, (9), 1440–1449.

A new angular discretization scheme based on the Daubechies' wavelets has been developed in recent studies. A decoupled S_N and wavelet expansion method was proposed. This paper discusses the limitations and improvements of this decoupled scheme. The scaling function, instead of the wavelet function, is applied as the basis function. It significantly improved the efficiency and computational stability. A new series of wavelets on the interval are applied instead of the 'wrapped wavelets', which eliminate the edge effect in the angular subdomain scheme. Based on the improvements, a wavelet-based neutron transport code package WAVTRAN is developed and the previous work is extended to the three-dimensional calculation and anisotropic scattering calculation. Numerical results demonstrate that the improvements are effective. Further investigations demonstrate that the wavelet-based angular discretization scheme is more powerful than the traditional ones in some highly anisotropic angular flux problems.

10/01881 Calculation of time-dependent neutronic parameters using Monte Carlo method

Shayesteh, M. and Shahriari, M. *Annals of Nuclear Energy*, 2009, 36, (7), 901–909.

A new code, named time-dependent Monte Carlo (TDMC), is developed for the calculation of neutronic parameters of multiplying systems. The code simulates the time-dependent neutron transport equation with explicit representation of delayed neutrons by using Monte Carlo method. Calculations with time-varying boundaries and/or cross sections are possible by this code. The resulting code is tested using benchmark problems and other methods that are available in the literature.

10/01882 Calibrating fault seal using a hydrocarbon migration model of the Oseberg Syd area, Viking Graben

Childs, C. *et al. Marine and Petroleum Geology*, 2009, 26, (6), 764–774.

It is widely acknowledged that fault rock capillary properties are important in controlling the distribution of hydrocarbons in sedimentary basins, and methods exist for predicting the capillary seal capacity of prospect bounding faults. However, fault seal capacity is rarely incorporated into models of hydrocarbon migration. This paper presents the results of migration modelling of the Oseberg Syd area of the Viking Graben incorporating fault rock capillary properties. Seal capacity is calculated in the model as a function of Shale Gouge Ratio (SGR), i.e. the percentage shale in the sequence moved past a point on a fault. Over 3000 model realizations were run for different SGR to fault seal capacity relationships and the calculated hydrocarbon distributions were compared with known distributions. Realizations were ranked according to the closeness of fit between model and actual oil–water contacts for seven traps. The best-fit to all seven traps was provided by realizations with significant seal capacity at SGR values greater than *ca.* 0.2; a value which is in agreement with an independently derived fault-by-fault calibration between SGR and seal capacity. The level of fill calculated for an individual trap is extremely sensitive to minor changes in the seal capacity relationship because it is controlled not only by the seal capacities of the faults that bound the trap, but also by the pattern of fill–spill of upstream traps. This sensitivity to minor changes in seal capacity introduces large uncertainties when fault seal capacity relationships are used in a predictive mode and emphasizes the requirement for migration modelling in fault seal prospect evaluation.

10/01883 Carbon Lorenz curves

Groot, L. *Resource and Energy Economics*, 2010, 32, (1), 45–64.

The purpose of this paper is twofold. First, it exhibits that standard tools in the measurement of income inequality, such as the Lorenz curve and the Gini-index, can successfully be applied to the issues of inequality measurement of carbon emissions and the equity of abatement policies across countries. These tools allow policy-makers and the general public to grasp at a single glance the impact of conventional distribution rules such as equal caps or grandfathering, or more sophisticated ones, on the distribution of greenhouse gas emissions. Second, using the Samuelson rule for the optimal provision of a public good, the Pareto-optimal distribution of carbon emissions is compared with the distribution that follows if countries follow Nash–Cournot abatement strategies. It is shown that the Pareto-optimal distribution under the Samuelson rule can be approximated by the equal cap division, represented by the diagonal in the Lorenz curve diagram.

10/01884 Chitin complex for the remediation of mine impacted water: geochemistry of metal removal and comparison with other common substrates

Ann Robinson-Lora, M. and Brennan, R. A. *Applied Geochemistry*, 2010, 25, (3), 336–344.

Remediation of mine impacted water (MIW) generally requires decreasing the acidity and concentrations of dissolved and/or particulate contaminants (SO_4^{2-}, metals and metalloids). By fulfilling these requirements in both laboratory and field trials, the sustainable composite waste material, crab-shell chitin complex (CC) has proven to be a promising substrate for MIW remediation, but has not yet been directly compared with other substrates under controlled conditions. In this study, remediation rates and metal removal mechanisms promoted by CC were evaluated and compared to the more commonly used lactate and spent mushroom compost (SMC) using sacrificial batch microcosms and geochemical modelling. Under comparable conditions with equivalent mass of substrate to water ratios, increases in pH were much faster in the microcosms containing CC than with the other substrates: CC increased the pH from pH 3.0 to near neutral in 3 d. In microcosms containing CC, steady alkalinity generation and acidity removal were observed at average rates of 26.5 and −25.2 mg $CaCO_3$/L-d, respectively. The activity of SO_4^{2-}-reducing bacteria was evident after 9 d of incubation, with average reduction rates of −17.8 mg SO_4^{2-}/L-d. Similar changes in alkalinity, acidity, and SO_4^{2-} were also observed in lactate-containing microcosms, but only after a 27 d lag period. No alkalinity generation or SO_4^{2-} reduction activity was observed in bottles containing SMC. Aluminum removal (100%) was eventually observed with all substrates, but occurred much faster with CC. Results from thermodynamic geochemical modelling indicate that Al removal was consistent with the precipitation of hydroxides and/or alunite. Iron removal was consistent with precipitation of Fe(III) oxides and Fe(II) sulfides, as well as sorption onto CC and SMC. The addition of Na lactate interfered with such mechanisms due to complexation effects. Chitin complex was the only substrate able to partially remove Mn (73%), likely due to the formation of rhodochrosite. The results of this study indicate that CC is an attractive substrate for treating metal-laden waste streams, especially those which are high in Mn.

10/01885 Energy metrics analysis of hybrid–photovoltaic (PV) modules

Tiwari, A. *et al. Applied Energy*, 2009, 86, (12), 2615–2625.

In this paper, energy metrics (energy payback time, electricity production factor and life cycle conversion efficiency) of hybrid photovoltaic (PV) modules have been analysed and presented for the composite climate of New Delhi, India. For this purpose, it is necessary to calculate: (1) the energy consumption in making different components of the PV modules and (2) the annual energy (electrical and thermal) available from the hybrid-PV modules. A set of mathematical relations have been reformulated for computation of the energy metrics. The manufacturing energy, material production energy, energy use and distribution energy of the system have been taken into account, to determine the embodied energy for the hybrid-PV modules. The embodied energy and annual energy outputs have been used for evaluation of the energy metrics. For a hybrid-PV module, it has been observed that the EPBT gets significantly reduced by taking into account the increase in annual energy availability of the thermal energy in addition to the electrical energy. The values of EPF and LCCE of hybrid PV module become higher as expected.

10/01886 Energy simulation of vertical greenery systems

Wong, N. H. *et al. Energy and Buildings*, 2009, 41, (12), 1401–1408.

This study simulated the effects of vertical greenery systems on the temperature and energy consumption of buildings. First, TAS software simulations were performed to determine their effects on thermal comfort and energy consumption. It was found that 100% greenery coverage from vertical greenery systems is effective in lowering the mean radiant temperature of a glass-façade building. Furthermore, to lower the energy cooling load significantly, the shading coefficient of plant species has to be low. Second, a thermal calculation of the envelope thermal transfer value (ETTV) was performed to obtain their effects on the thermal performance of building envelope. Results showed a linear correlation between shading coefficient and leaf area index where a lower shading coefficient leads to a greater thermal insulation. A 50% greenery coverage from vertical greenery systems and a shading coefficient of 0.041 reduce the ETTV of a glass facade building by 40.68%. Lastly, vertical greenery systems in mitigating the urban heat island effect within an estate were simulated using STEVE model. The increase of greenery coverage from vertical greenery systems was most significantly felt with a drop in the minimum estate air temperature throughout a large region of the estate.

10/01887 Forecasting energy consumption in Taiwan using hybrid nonlinear models

Pao, H. T. *Energy*, 2009, 34, (10), 1438–1446.

The total consumption of electricity and petroleum energies accounts for almost 90% of the total energy consumption in Taiwan, so it is critical to model and forecast them accurately. For univariate modelling, this paper proposes two new hybrid non-linear models that combine a linear model with an artificial neural network (ANN) to develop adjusted forecasts, taking into account heteroscedasticity in the model's input. Both of the hybrid models can decrease round-off and prediction errors for multi-step-ahead forecasting. The results suggest that the new hybrid model generally produces forecasts which, on the basis of out-of-sample forecast encompassing tests and comparisons of three different statistic measures, routinely dominate the forecasts from conventional linear models. The superiority of the hybrid ANNs is due to their flexibility to account for potentially complex non-linear relationships that are not easily captured by linear models. Furthermore, all of the linear and non-linear models have highly accurate forecasts, since the mean absolute percentage forecast error (MAPE) results are less than 5%. Overall, the inclusion of heteroscedastic variations in the input layer of the hybrid univariate model could help improve the modelling accuracy for multi-step-ahead forecasting.

10/01888 Higher-harmonic focused-wave forces on a vertical cylinder

Ma, Y. *et al. Ocean Engineering*, 2009, 36, (8), 595–604.

This paper considers higher-harmonic forces due to wave focusing on a vertical circular cylinder. A series of experiments has been conducted in a wave flume. The first six-harmonic components of the measured wave forces are analysed using the scale-averaged wavelet spectrum. It is noted that due to the transient nature of focused (freak) waves, Fourier analysis would not provide equivalent information to that gleaned from the analyses used herein. The results for the experiments with very steep wave crests show significant amplitudes at the fourth and fifth harmonics. These harmonics exhibit amplitudes that are the same order as the second harmonic, but much larger than those of the third harmonic. The wavelet-based bicoherence is used to detect the quadratic non-linearity of the measured forces. And the bicoherence spectra reveal the primary mathematical reason for the existence of the striking amplitudes of the fourth and fifth harmonics: the interaction between the lower-harmonic components couple more strongly with the fourth and fifth harmonics, thus the fourth and fifth harmonics glean more energy than those of the third-harmonic components. However, the physical explanation for this remains elusive.

10/01889 Measurement of meteorological data based on wireless data acquisition system monitoring

Benghanem, M. *Applied Energy*, 2009, 86, (12), 2651–2660.

Estimation of solar energy potential of a region requires detailed solar radiation climatology, and it is necessary to collect extensive radiation data of high accuracy covering all climatic zones of the region. In this regard, a wireless data acquisition system (WDAS) would help to estimate solar energy potential considering the remote region's energy requirement. This article explains the design and implementation of WDAS for assessment of solar energy. The proposed system consists of a set of sensors for measuring meteorological parameters. The collected data are first conditioned using precision electronic circuits and then interfaced to a PC using RS232 connection via wireless unit. The LabVIEW program is used to further process, display and store the collected data in the PC disk. The proposed architecture permits the rapid system development and has the advantage of flexibility and it can be easily extended for controlling the renewable energy systems like photovoltaic system. The WDAS with executive information systems and reporting tools helps to tap vast data resources and deliver information.

10/01890 Method using gas chromatography to determine the molar flow balance for proton exchange membrane fuel cells exposed to impurities

Bender, G. *et al. Journal of Power Sources*, 2009, 193, (2), 713–722.

An understanding of the potentially serious performance degradation effects that trace level contaminants can cause in proton exchange membrane fuel cells (PEMFCs) is crucial for the successful deployment of PEMFC for commercial applications. An experimental and analytic methodology is described that employs gas chromatography (GC) to accurately determine the concentration of impurity species in the fuel and oxidant streams of a PEMFC. This study also shows that the accurate determination of the contaminant concentrations at the anode and cathode inlets and outlets provides a means to quantify reactions of contaminants within the cell and to identify diffusive mass transport across the membrane. High data accuracy down to sub-ppm contaminant levels is required and was achieved by addressing several challenges pertaining to experimental setup and data analysis which are both discussed in detail. The application of the methodology is demonstrated using carbon monoxide and toluene which were injected into the cell at concentrations between 1 and 10 ppm and 20 and 60 ppm, respectively. Both impurities were observed to react in the fuel cell: carbon monoxide to carbon dioxide, and toluene to methylcyclohexane. For both contaminants closure of the molar flow balances to within 3% was achieved even at the low contaminant concentrations. This allowed the extent of both reactions at the applied operating conditions to be quantified. The presented methodology is shown to be a valuable tool for investigating the effects and reactions of trace contaminants in fuel cells and for providing critical insights into the mechanisms responsible for the associated performance degradation.

10/01891 Monthly average clear-sky broadband irradiance database for worldwide solar heat gain and building cooling load calculations

Gueymard, C. A. and Thevenard, D. *Solar Energy*, 2009, 83, (11), 1998–2018.

This paper establishes the formulation of a new clear-sky solar radiation model appropriate for algorithms calculating cooling loads in buildings. The aim is to replace the ASHRAE clear-sky model of 1967, whose limitations are well known and are reviewed. The new model is derived in two steps. The first step consists of obtaining a reference irradiance dataset from the REST2 model, which uses a high-performance, validated, two-band clear-sky algorithm. REST2 requires detailed inputs about atmospheric conditions such as aerosols, water vapour, ozone, and ground albedo. The development of global atmospheric datasets used as inputs to REST2 is reviewed. For the most part, these datasets are derived from space observations to guarantee universality and accuracy. In the case of aerosols, point-source terrestrial measurements were also used as ground truthing of the satellite data. The second step of the model consists of fits derived from a REST2-based reference irradiance dataset. These fits enable the derivation of compact, but relatively accurate expressions, for beam and diffuse clear-sky irradiance. The fitted expressions require the tabulation of only two pseudo-optical depths for each month of the year. The resulting model, and its tabulated data, are expected to be incorporated in the 2009 edition of the ASHRAE *Handbook of Fundamentals*.

10/01892 New computation method for stratification pipes of solar storage tanks

Göppert, S. *et al. Solar Energy*, 2009, 83, (9), 1578–1587.

The efficiency of low-flow solar systems is strongly influenced by the quality of the thermal stratification in the storage tank. The better a thermal stratification can be generated and maintained, the higher can be the yield of the solar system. Fluid mechanical charge systems are often used for this purpose, which cause, however, undesirable sucking effects. Therefore, the knowledge of the appearing fluid flows as well as the knowledge of the consequences of constructive changes are very important for the design of such charge systems. However, simulations with computational fluid dynamics (CFD) are very costly and time-consuming. In this article a new and much simpler computation method is introduced making the determination of the individual fluid flows and the estimation of the effects of constructive changes possible. The computations can be carried out within short time. The comparison with CFD gives a qualitatively good agreement for a simple charge system. The results of a constructive modification of the charge system reducing the sucking effect are discussed. The remaining quantitative differences result from the discrepancies between the non-ideal behaviour of the real fluid and the model assumptions and point out improvement potentials.

10/01893 Numerical investigation of the first bifurcation for natural convection of fluids enclosed in a 2D square cavity with Pr lower than 1.0

Wang, X. *et al. Energy Conversion and Management*, 2009, 50, (10), 2504–2512.

This article presents a numerical study of the effect of the Prandtl number on the first bifurcation of natural convection for fluids enclosed in a 2D square cavity subject to a horizontal temperature gradient. The natural convection equations are solved using a second-order Euler–Taylor–Galerkin (ETG) finite element method of fractional steps. Influence of the mesh resolution on the numerical investigation is analysed first on 10 sets of uniform square element meshes while the Rayleigh numbers are 10^4 and 10^5 keeping $Pr = 0.71$. Variations of the averaged Nusselt number and its relative error in the results provided by the benchmark computation of Davis with the grids are used to find the role of mesh resolution. As for $Ra = 10^4$ and 10^5, Nu_{AVER} increases first with the increase in the number of grids used. And for each Ra, Nu_{AVER} tends to be independent of the number of elements when it is higher than 80×80. Grids (101×101) are then used in the study to capture the first bifurcation of natural convection. The bisection method and the flow patterns are utilized to estimate the critical Rayleigh number for 11 different fluids for which $Pr \geq 1.0$. It can be deduced from the results presented that Ra_{Cr} decreases with the increase in Pr. Variation of Ra_{Cr} with Pr is also fitted to estimate Ra_{Cr} for any fluids for which $Pr \geq 1.0$ directly. It is also observed that the global flow cores are inclined for each Pr and that the inclination degree increases in anticlockwise direction with Pr.

10/01894 Numerical simulation of three-dimensional flow dynamics in a hot water storage tank

Ievers, S. and Lin, W. *Applied Energy*, 2009, 86, (12), 2604–2614.

Research has shown that the thermal performance of a hot water system can be increased by maximizing the level of thermal stratification within the storage tank, which could lead to huge energy saving. To analyse the effects of tank geometry and operating conditions on the thermal stratification within a storage tank, seven three-dimensional models have been numerically simulated by using the computational fluid dynamics program Fluent with realistic boundary and initial conditions applied. The level of thermal stratification in each model has been quantified using exergy analyses. The results show that increasing the tanks height/diameter aspect ratio, decreasing inlet/outlet flow rates and moving the inlet/outlet to the outer extremities of the tank all result in increasing levels of thermal stratification.

10/01895 Offshore wind energy development in the exclusive economic zone: legal and policy supports and impediments in Germany and the US

Portman, M. E. *et al. Energy Policy*, 2009, 37, (9), 3596–3607.

The development of renewable energy as a major component of efforts to combat climate change serves as the impetus for the location of energy production facilities in coastal ocean space. Yet, while many coastal nations see offshore renewable energy development as an important way forward, the speed and manner in which these efforts take shape vary dramatically. This paper assesses the role of coastal nations' domestic legal and policy frameworks in the siting of offshore renewable energy facilities in areas under federal jurisdiction. It focuses on two nations – Germany and the United States. Both have articulated their interest in renewable offshore energy, but while Germany has approved many offshore sites, recent US proposals have for the most part stalled. Based on a review of legal and policy documents, laws and regulations, academic literature, and interviews, this research identifies and compares factors that figure most prominently for the development of offshore renewable energy policies. Comparisons are organized under four categories: the regulatory framework, the public's role in siting, targeted economic mechanisms, and indirect mechanisms. The paper concludes with observations about prominent supports and impediments and suggestions for further research.

10/01896 On the frequency-dependent specific heat and TMDSC: constitutive modelling based on thermodynamics with internal state variables

Lion, A. and Yagimli, B. *Thermochimica Acta*, 2009, 490, (1–2), 64–74.

To develop constitutive models to represent the thermomechanically chemically coupled behaviour of curing resins, vulcanizing elastomers or melting and crystallizing polymers the technique of DSC is extremely helpful. In the present study, the method of TMDSC is interpreted and evaluated in the context of thermodynamics with internal state variables. The balance equation of energy and the dissipation principle in the form of the Clausius–Duhem inequality form the theoretical basis of this study. Since the pressure and the temperature are the external variables in DSC, the specific Gibbs free energy is used as thermodynamic potential. It depends on temperature, stress and a set of internal state variables to represent the microstructure of the material on a phenomenological basis. The temperature- and internal variable-induced changes in the Gibbs free energy are approximated by a Taylor series up to second order terms. As a substantial result of this work, closed-form expressions for the dynamic calorimetric response due to harmonic temperature perturbations and the frequency-dependent complex heat capacity are derived. The theory allows a physical interpretation of the complex heat capacity and its underlying phenomena and is in accordance with experimental observations from literature.

10/01897 On-line measurement of separation dynamics in primary gas/oil/water separators: challenges and technical solutions – a review

Jaworski, A. J. and Meng, G. *Journal of Petroleum Science and Engineering*, 2009, 68, (1–2), 47–59.

The aim of this paper is to provide a comprehensive review of the current measurement technologies available for on-line monitoring of the performance of the gas/oil/water separators, which are commonly used as the first stage of crude oil processing. First, a short overview is given of the fluid physics governing the separation processes and the design of separation vessels. Simple theoretical models of separation physics are briefly reviewed and the process challenges outlined. This is followed by the description of existing measurement systems, those entering the market and likely future developments. The measurement systems are broadly divided into three categories: (1) those based on the assumption of a complete phase separation within the vessel; (2) those based on the concept of an array of sensors distributed across the heterogeneous layers, hence not requiring any assumptions regarding the actual phase distribution; and (3) more complex systems enabling cross-sectional imaging in the industrial process tomography sense.

10/01898 Optimization of network planning by the novel hybrid algorithms of intelligent optimization techniques

Sadegheih, A. *Energy*, 2009, 34, (10), 1539–1551.

This paper proposes a new hybrid algorithm Meta-heuristic for the problem of network planning systems. The main goal of this paper is, to develop an efficient optimization tool which will minimize the cost functions of the stated optimization problems in network planning systems. The following are the objectives of the research: to investigate the capabilities of genetic algorithm, simulated annealing and tabu search for the defined optimization tasks; to develop a hybrid optimization algorithm which will produce improved iterations compared to those found by GA, SA, and TS algorithms. The performance of the hybrid algorithm is illustrated and six hybrid algorithms are developed, to improve the iterations obtained. The cost function of this problem consists of the capital investment cost in discrete form, the cost of transmission losses and the power generation costs. It is advantageous to use exact DC load flow constraint equations based on the modified form of Kirchhoff's second law because the iterative process for line addition is not required. Hence, the computation time is decreased. Finally, the hybrid VI shows to be a very good option for network planning systems given that it obtains much accentuated reductions of iteration, which is very important for network planning.

10/01899 Prediction of torque and specific fuel consumption of a gasoline engine by using artificial neural networks

Togun, N. K. and Baysec, S. *Applied Energy*, 2010, 87, (1), 349–355.

This study presents an artificial neural network (ANN) model to predict the torque and brake specific fuel consumption of a gasoline engine. An explicit ANN based formulation is developed to predict torque and brake specific fuel consumption of a gasoline engine in terms of spark advance, throttle position and engine speed. The proposed ANN model is based on experimental results. Experimental studies were completed to obtain training and testing data. Of all 81 data sets, the training and testing sets consisted of randomly selected 63 and 18 sets, respectively. An ANN model based on a back-propagation learning algorithm for the engine was developed. The performance and an accuracy of the proposed ANN model are found satisfactory. This study demonstrates that ANN is very efficient for predicting the engine torque and brake specific fuel consumption. Moreover, the proposed ANN model is presented in explicit form as a mathematical function.

10/01900 Role of alternative electron acceptors (AEA) to control methane flux from waterlogged paddy fields: case studies in the southern part of West Bengal, India

Mukherjee, R. *et al. International Journal of Greenhouse Gas Control*, 2009, 3, (5), 664–672.

The rice fields, depleted of O_2, contain large amount of moisture and organic substrates to provide an ideal anaerobic environment for methanogenesis and are one of the principal anthropogenic sources of methane. In order to mitigate this emission alternative electron acceptors (AEA) were altered in the soil. The experiments were carried out in four seasons at the site of Balarampur, near Baruipur, South 24 Parganas, West Bengal, namely September–December 2005 (Cultivar: Sundari), February–May 2006 (Cultivar: Sundari), September–December 2006 and February–May 2007 (Cultivar: Swarna-Pankaj). The seasonal average methane flux (Fe treated), for the cultivar type ‘Sundari’ (season: September–December 2005), is $4.41\,\mathrm{t\,ha^{-1}}$, as compared to the value of $6.40\,\mathrm{t\,ha^{-1}}$ for the untreated soil. Similarly for February–May 2006, the seasonal average methane flux (Fe treated) is $5.52\,\mathrm{t\,ha^{-1}}$, whereas the untreated flux is $5.69\,\mathrm{t\,ha^{-1}}$. In the third and fourth seasons there were two treatments with ammonium thiosulfate and ferric hydroxide. The seasonal average methane flux (treatment: ammonium thiosulfate) is $4.35\,\mathrm{t\,ha^{-1}}$ and $5.41\,\mathrm{t\,ha^{-1}}$ respectively, whereas for the ferric hydroxide treated soil it is $4.35\,\mathrm{t\,ha^{-1}}$ and $6.14\,\mathrm{t\,ha^{-1}}$ respectively. The properties related to the nutrient quality of the harvested paddy seeds supplement these results.

10/01901 Safety-barrier diagrams as a tool for modelling safety of hydrogen applications

Duijm, N. J. and Markert, F. *International Journal of Hydrogen Energy*, 2009, 34, (14), 5862–5868.

Safety-barrier diagrams have proven to be a useful tool in documenting the safety measures taken to prevent incidents and accidents in process industry. Especially during the introduction of new hydrogen technologies or applications, as for example hydrogen refuelling stations, safety-barrier diagrams are considered a valuable supplement to other traditional risk analysis tools to support the communication with authorities and other stakeholders during the permitting process. Another advantage of safety-barrier diagrams is that they highlight the importance of functional and reliable safety barriers in any system and here is a direct focus on those barriers that need to be subject to safety management in terms of design and installation, operational use, inspection and monitoring, and maintenance. Safety-barrier diagrams support both quantitative and qualitative approaches. The paper will describe the background and syntax of the methodology and demonstrate the usefulness of such diagrams for hydrogen technologies.

10/01902 Selecting parameters for the environmental interpretation of peat molecular chemistry – a pyrolysis-GC/MS study

Schellekens, J. *et al. Organic Geochemistry*, 2009, 40, (6), 678–691.

A number of samples from a deep peat bog in Tierra del Fuego were analysed using pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS) in order to extract parameters that might be used to interpret the peat chemistry in terms of vegetation change, anaerobic and aerobic decomposition, and fire incidence. The choice of parameters was based on factor analysis of 177 pyrolysis products, quantified for 13 samples, separated into extract and residue, as well as the total samples. Factor analysis of extracts, residues and total samples yielded similar classifications in terms of vegetation and decomposition. Pyrolysis products and ratios that most clearly differentiated samples were used to interpret the depth profile. Although interpretation was not always straightforward, indications of parameters to describe vegetation shifts, aerobic and anaerobic decomposition, and fire largely coincided. These parameters will be used in a forthcoming study for a more complete interpretation of the peat profile.

10/01903 Sky luminance/radiance model with multiple scattering effect

Kocifaj, M. *Solar Energy*, 2009, 83, (10), 1914–1922.

Angular distribution of the diffuse light essentially varies with the physical state of a disperse media. The main factors influencing the optical behaviour of the Earth’s atmosphere are the total optical thickness, the scattering ability of atmospheric layers, and also the reflectance of underlying surface. Any model aspiring to be more universal and still satisfactory accurate must at least account for these quantities. The paper presents the theoretically derived equation simulating the sky luminance/radiance under various meteorological conditions. Because the radiative transfer equation in plan-parallel atmosphere is solved exactly, the proposed approximation formula is physically well founded. Compared with other, predominately empirical models, the presented approach accepts the basic principles of light scattering in a turbid environment and the model is spectral in its nature (contrary to empirical models in current use). In addition, the contribution of multiple scattering is taken into account. A set of free parameters, otherwise used as weighting factors for individual optical effects, makes the model easily scalable and applicable for a wide range of optical states of the atmosphere.

10/01904 Sloshing waves and resonance modes of fluid in a 3D tank by a time-independent finite difference method

Wu, C.-W. and Chen, B.-F. *Ocean Engineering*, 2009, 36, (6–7), 500–510.

A 3D time-independent finite difference method is developed to solve for wave sloshing in a three-dimensional tank excited by coupled surge and sway motions. The 3D equations of fluid motion are derived in a moving coordinate system. The three-dimensional tank, with an arbitrary depth and a square base, is subjected to a range of excitation frequencies with motions that exhibit multiple degrees of freedom. For demonstration purposes the numerical scheme is validated by a benchmark study. Five types of sloshing waves were observed when the tank is excited by various excitation frequencies. A spectral analysis identified the resonant frequencies of each type of wave and the results show a strong correlation between resonant modes and the occurrence of the sloshing wave types. The method can be used to simulate fluid sloshing in a 3D tank with six-degrees of freedom.

10/01905 Spectroscopic sensor techniques applicable to real-time biodiesel determination

Chuck, C. J. *et al. Fuel*, 2010, 89, (2), 457–461.

The term biodiesel refers to the fatty acid alkyl esters (FAAE) derived from vegetable, animal or waste oil feedstocks. This alternative fuel is increasingly becoming a significant part of the transport sector with over 10 million tonnes sold in the EU in 2007. Currently a small amount of biodiesel (presently 3.5% in the UK) is present in diesel fuel but this could rise to up to 30% in the medium term. As biodiesel is not one chemical compound but an amalgamation of different FAAE, the physical properties of the diesel fuel are not only dependent on the amount of biodiesel in the diesel fuel (blend level) but also on the fatty acid profile of the biodiesel. This paper reports on an initial study to assess a range of current techniques which could be used in the future as a basis to determine blend level in unknown samples of diesel and gain further information on the fatty acid profile of the biodiesel in the blend. The three techniques applied were FT-IR spectroscopy, refractive index and UV–Vis spectroscopy.

10/01906 Strategic analysis methodology for energy systems with remote island case study

Krumdieck, S. and Hamm, A. *Energy Policy*, 2009, 37, (9), 3301–3313.

A strategic analysis methodology is presented for adaptive energy systems engineering to realize an optimal level of service in the context of a community’s social, economic, and environmental position. The groundwork stage involves characterizing the social context, assessing available energy resources, identifying environmental issues, setting eco-resource limits, and quantifying socio-economic constraints for a given region. A spectrum of development options is then constructed according to the range of energy service levels identified for the sector under study. A spectrum of conceptual energy systems is generated and infrastructure investments and resource use are modelled. The outcome is a matrix of energy system investment possibilities for the range of energy demand levels reflecting the values, ideas, and expectations expressed by the community. These models are then used to assess technical feasibility and economic, environmental and social risk. The result is an easily understood graphical depiction of local aspirations, investment options, and risks which clearly differentiates development opportunities from non-viable concepts. The approach was applied to a case study on Rotuma, an isolated Pacific Island. The case study results show a clear development opportunity space for Rotuma where desired energy services are in balance with investment sources, resource availability, and environmental constraints.

10/01907 Technical and economical tools to assess customer demand response in the commercial sector

Bel, C. Á. *et al. Energy Conversion and Management*, 2009, 50, (10), 2605–2612.

The authors present a methodology to evaluate and quantify the economic parameters (costs and benefits) attached to customer electricity consumption by analysing the service provided by the different ‘pieces’ of absorbed electricity. The first step of this methodology is to perform a process oriented market segmentation to identify segments according to their flexibility potential. After that, a procedure based on comprehensive simulations to identify and quantify the actual demand that can be managed in the short term is presented and, finally, the required economic analysis is performed. The methodology, which is demonstrated with some applications to the commercial sector, not only helps the customers to integrate in flexible distribution systems but also offers the necessary economical parameters for them to integrate in electricity markets.

10/01908 Two practical methods for unionized energy grid construction in continuous-energy Monte Carlo neutron transport calculation

Leppänen, J. *Annals of Nuclear Energy*, 2009, 36, (7), 878–885.

A considerable speed-up in continuous-energy Monte Carlo neutron transport calculation can be achieved by using the same unionized energy grid for all point-wise reaction cross-sections. This speed-up results from the fact that time-consuming grid iteration is reduced to minimum, and if the unionized grid is constructed by combining the grids of all nuclides, there is no loss of data or accuracy in the calculation. The drawback of this approach is that computer memory is wasted for storing a large number of redundant data points. Memory usage may become a problem, especially in burn-up calculations, in which the irradiated materials consist of several hundred actinide and fission product nuclides. The grid size easily increases to over 1 million points, requiring tens of gigabytes of memory for storing the cross section data. This paper presents two practical methods for reducing the memory demand, while trying preserve the accuracy of the original data. The calculation routines are included in the PSG2/Serpent Monte Carlo reactor physics burn-up calculation code and the methods are tested in a BWR assembly burn-up calculation.

10/01909 Validity ranges of three analytical solutions to heat transfer in the vicinity of single boreholes

Philippe, M. *et al. Geothermics*, 2009, 38, (4), 407–413.

In ground-coupled heat pump systems, accurate prediction of transient ground heat transfer is important to establish the required borehole length and to determine precisely the resulting fluid temperature. Three analytical solutions to transient heat transfer in the vicinity of geothermal boreholes are presented. These solutions are referred to as the infinite line source (ILS), the infinite cylindrical source (ICS) and the finite line source (FLS) models, which vary in complexity and are based on simplifications of the borehole geometry. The results of these models are compared and their validity domains are determined.

Fuel cell technology

10/01910 A combined methanol autothermal steam reforming and PEM fuel cell pilot plant unit: experimental and simulation studies

Ouzounidou, M. *et al. Energy*, 2009, 34, (10), 1733–1743.

An integrated system for hydrogen production via autothermal steam reforming of methanol and consequent power generation in a polymer electrolyte membrane (PEM) fuel cell has been developed and operated at CPERI. The pilot plant comprises an autothermal reforming reactor to produce hydrogen, a preferential oxidation reactor (PROX) to reduce CO concentration below 50 ppm and a PEM fuel cell for power generation. The present paper deals with the study of this system, both from an experimental and a theoretical point of view. The experimental work aims to: (a) examine the effect of the reforming temperature on methanol conversion and on the effluent stream concentration, (b) investigate the effect of reaction temperature and O_2/CO ratio on the performance of the PROX reactor, and (c) evaluate the operation of a 10-cell PEM fuel cell, using pure hydrogen and air at three temperature levels. The experimental data are subsequently utilized for the validation of one-dimensional pseudo-homogeneous models that have been developed for the two reactors and also for the identification of the voltage–current characteristic curve of the PEM fuel cell. The validated models are then used to investigate the behaviour and explore the interactions, both static and dynamic, among the various process subsystems.

10/01911 A rapid break-in procedure for PBI fuel cells

Tingelöf, T. and Ihonen, J. K. *International Journal of Hydrogen Energy*, 2009, 34, (15), 6452–6456.

Different break-in procedures for phosphoric acid doped polybenzimidazole membrane fuel cells (PBI-FC) have been studied, including voltage cycling and the use of constant current at different temperatures. A rapid break-in procedure consisting of high-temperature constant current break-in and relaxation has been developed. The break-in procedure is considered suitable for contamination and performance studies.

10/01912 A review of biomass-derived fuel processors for fuel cell systems

Xuan, J. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (6–7), 1301–1313.

Fuel cell coupled with biomass-derived fuel processor can convert renewable energy into a useful form in an environmental-friendly and CO_2-neutral manner. It is considered as one of the most promising energy supply systems in the future. Biomass-derived fuels, such as ethanol, methanol, biodiesel, glycerol, and biogas, can be fed to a fuel processor as a raw fuel for reforming by autothermal reforming, steam reforming, partial oxidation, or other reforming methods. Catalysts play an important role in the fuel processor to convert biomass fuels with high hydrogen selectivity. The processor configuration is another crucial factor determining the application and the performance of a biomass fuel processing system. The newly developed monolithic reactor, micro-reactor, and internal reforming technologies have demonstrated that they are robust in converting a wide range of biomass fuels with high efficiency. This paper provides a review of the biomass-derived fuel processing technologies from various perspectives including the feedstock, reforming mechanisms, catalysts, and processor configurations. The research challenges and future development of biomass fuel processor are also discussed.

10/01913 An easy-to-approach and comprehensive model for planar type SOFCs

Li, P. W. *et al. International Journal of Hydrogen Energy*, 2009, 34, (15), 6393–6392.

An easy-to-approach and comprehensive mathematical model for planar type solid oxide fuel cells is presented in the current work. It provides a tool for researchers to conduct parametric studies with less-intensive computation in order to grasp the fundamentals of coupled mass transfer, electrochemical reaction, and current conduction in a fuel cell. In the model, the analysis for the mass transfer polarization at a known average fuel cell operating temperature is based on an average mass transfer model analogous to an average heat transfer process in a duct flow. The effect of the species’ partial pressure at electrode/electrolyte interfaces is therefore included in the exchange current density for activation polarizations. An electrical circuit for the current and ion conduction is used to analyse the ohmic losses from anode current collector to cathode current collector. The three types of over-potentials caused by different polarizations in a planar type solid oxide fuel cell can be identified and compared. The effects of species concentrations, properties of fuel cell components to the voltage–current performance of a fuel cell at different operating conditions are studied. Optimization of the dimensions of flow channels and current-collecting ribs is also presented. The model is of significance to the design and optimization of solid oxide fuel cells for industrial application.

10/01914 Analysis of the energy efficiency of innovative ATR-based PEM fuel cell system with hydrogen membrane separation

Salemme, S. *et al. International Journal of Hydrogen Energy*, 2009, 34, (15), 6384–6392.

This study reports a simulative energy efficiency analysis performed on innovative fuel processor – PEM fuel cell systems in which hydrogen is produced via methane autothermal reforming, separated with a membrane unit coupled with a water gas shift reactor and then converted into electric energy by means of the PEM fuel cell. Two basic configurations are investigated: one with the membrane unit placed downstream the water gas shift reactor and the other with the membrane unit embedded into the water gas shift reactor. The results are discussed and compared with the case of a fuel processor constituted by an autothermal reforming reactor followed by two water gas shift reactors and a preferential CO-oxidation reactor. Pressure, steam to methane and oxygen to methane inlet ratios are explored as operation variables. The effect of addition of steam as sweep gas into the permeate side of the membrane is also presented and discussed.

10/01915 Design, integration and demonstration of a 50 W JP8/kerosene fueled portable SOFC power generator

Cheekatamarla, P. K. *et al. Journal of Power Sources*, 2009, 193, (2), 797–803.

A man-portable solid oxide fuel cell (SOFC) system integrated with desulfurized JP8 partial oxidation (POX) reformer was demonstrated to supply a continuous power output of 50 W. This paper discusses some of the design paths chosen and challenges faced during the thermal integration of the stack and reformer in aiding the system startup and shutdown along with balance of plant and power management solutions. The package design, system capabilities, and test results of the prototype unit are presented.

10/01916 Life time test in direct borohydride fuel cell system

Jamard, R. *et al. Journal of Power Sources*, 2009, 193, (2), 779–787.

The electric performances of direct borohydride fuel cells (DBFCs) are evaluated in terms of power density and life time with respect to the $NaBH_4$ concentration. A DBFC constituted of an anionic membrane, a $0.6\,mg_{Pt}\,cm^{-2}$ anode and a commercial non-platinum based cathode led to performances as high as $200\,mW\,cm^{-2}$ at room temperature and with natural convection of air. Electrochemical life time test at $0.55\,mA\,cm^{-2}$ with a 5 M $NaBH_4$/1 M NaOH solution shows a voltage diminution of $1\,mV\,h^{-1}$ and a drastic drop of performances after 250 h. The life time is twice longer with 2 M $NaBH_4$/1 M NaOH solution (450 h) and the voltage decrease is $0.5\,mV\,h^{-1}$. Analyses of the components after life time tests indicate that voltage loss is mainly due to the degradation of the cathode performance. Crystallization of carbonate and borate is observed at the cathode side, although the anionic membrane displays low permeability to borohydride.

10/01917 Palladium–polyelectrolyte hybrid nanoparticles for hydrogen sensor in fuel cells

Ohara, S. *et al. Journal of Power Sources*, 2009, 193, (1), 367–370.

The authors prepared palladium–polyelectrolyte hybrid nanoparticles by using a metallization of polyelectrolyte. They also selected polyacrylic acid (PAA) as a polyelectrolyte and reduced the palladium ions on the PAA by using ascorbic acids in order to form a unique spherically shaped mosslike hybrid nanoparticle. Palladium (Pd) can absorb hydrogen to become PdH_x, and the storage of hydrogen increases the electrical resistance and volume of Pd materials. The use of this material is attracting growing interest as a reliable, cheap, ultracompact, and safe hydrogen sensor for use in fuel cells. This study showed the utilization of the Pd–PAA hybrid nanoparticles as a highly sensitive hydrogen sensor that exhibited a switch response depending on volume expansion in a cyclic atmosphere exchange.

10/01918 Thermo-fluid and electrochemical modeling of a multi-bundle IP-SOFC – technology for second generation hybrid application

Mounir, H. *et al. Energy Conversion and Management*, 2009, 50, (10), 2685–2692.

This paper describes an electrochemical model, which studies the performance of multi-bundles integrated-planar solid oxide fuel cell (IP-SOFC strip) fuelled by pure hydrogen. Following a description of the basic geometries and general premises the approaches and simplifications for the calculation of ohmic resistance, gas flow, heat and mass transfers are given. The effect of fuel pressure ratio and the temperature variation are investigated in a parameter study. The model results have been validates well with experimental data obtained from a full-size prototype of IP-SOFC technology for the second generation hybrid application; it is found that the ohmic and cathode activation overpotentials represent a major loss in fuel cell voltage. The results obtained from both strips also demonstrated acceptable performance and good reproducibility bundles to bundles at 900 °C. These results indicated weak effect of parameter variation on the bundles to bundles performances.

10/01919 Thermodynamic model for exergetic performance of a tubular SOFC module

Akkaya, A. V. *et al. Renewable Energy*, 2009, 34, (7), 1863–1870.

A tubular solid oxide fuel cell (TSOFC) module fed by methane is modelled and analysed thermodynamically from the exergy point of view in this paper. The model of the TSOFC module consists of mixer, pre-reformer, internal reforming fuel cell group, afterburner and internal pre-heater components. The model of the components forming module is given based on mass, energy and exergy balance equations. The developed thermodynamic model is simulated, and the obtained performance characteristics are compared and validated with the experimental data taken from the literature concerning the TSOFC module. For exergetic performance analysis, the effects of operating variables such as current density, pressure, and fuel utilization factor on exergetic performances (module exergy efficiency, module exergetic performance coefficient, module exergy output and total exergy destruction rate, and components' exergy efficiencies, exergy destruction rates) are investigated. From the analysis, it is determined that the biggest exergy loss stems from exhaust gasses. Other important sources of exergy destruction involve fuel cell group and afterburner. Consequently, the developed thermodynamic model is expected to provide not only a convenient tool to determine the module exergetic performances and component irreversibility but also an appropriate basis to design complex hybrid power generation plants.

15 ENVIRONMENT

Pollution, health protection, applications

10/01920 Air versus terrestrial transport modalities: an energy and environmental comparison

Federici, M. *et al. Energy*, 2009, 34, (10), 1493–1503.

In the last 15 years, worldwide air transportation has grown at an average yearly rate of 4.5%. Forecasts confirm that this could be the average increase rate for the next 20 years, although recent oscillation of oil price translated into a slowing down of such a trend, with several air companies forced out of business. Within this framework, low cost airlines keep increasing their market share, in so making the airplane compete with terrestrial transport modalities, not only for medium and long distances, but also for short trips. This is because air transport is obviously faster than transport by trains and cars, and most often it also is a cheaper option in money terms. In spite of its apparent success, air transportation is a source of concern for many analysts, because it is considered as the more energy intensive and polluting transport modality. In order to explore the correctness of such an issue, air transportation was compared to high-speed trains and other modern terrestrial modalities, by using a 'whole-system' approach. The present study applies an LCA-like approach, by taking into account all the energy and materials directly and indirectly required to make and operate infrastructures (i.e. tunnels, railways, highways) and vehicles. Efficiency and environmental loading are assessed by means of material flow accounting, embodied energy analysis and emergy synthesis methods. Results point out that the gap among the environmental performances of air, road and railway modalities is significantly narrower than expected. The thermodynamic and environmental costs of road and railway infrastructure cannot be disregarded as negligible. In a selected number of cases these transport modalities perform even worse than the air transportation mode, where infrastructures play a much smaller role.

10/01921 Carbon emission offsets for aviation-generated emissions due to international travel to and from New Zealand

Smith, I. J. and Rodger, C. J. *Energy Policy*, 2009, 37, (9), 3438–3447.

International air transport emissions are not subject to liability under the Kyoto Protocol. However, pressure is mounting globally for international aviation to be included in post-Kyoto arrangements. In the absence of international collective action, a number of so-called carbon offsetting schemes have emerged that allow individual travellers and companies to compensate for their international air travel emissions. These schemes offer technological solutions, such as planting sink forests to sequester emissions. To consider the implications of future collective action, this paper presents a case study assessment of the physical feasibility of five schemes for all short duration journeys to and from New Zealand. This is the first comprehensive national-level case study assessment of competing offsetting options for international aviation emissions in the peer-reviewed literature. The CO_2-e emissions produced by the air travel of international visitors to New Zealand, and for New Zealand residents travelling overseas, is calculated in this paper to be 7893 and 3948 Gg, respectively, in 2005. It is then shown that no single offsetting scheme targeted inside the country appears physically and/or politically realistic. This indicates the sheer size of these emissions, and the challenge that the international community faces for collective action on this matter.

10/01922 Characteristics and potential environmental consequence of weathered materials in the surface layer of a spontaneously combusting mine spoil stockpile

Lu, W. *et al. Applied Geochemistry*, 2010, 25, (3), 496–501.

In this study an investigation was carried out to characterize the sulfidic mine spoils in the surface layer of a spontaneously combusting waste rock stockpile. The objective was to assess its potential impacts on acid mine drainage generation. The results show that there were substantial amounts of elemental S and various sulfate minerals in the weathered materials, indicating the occurrence of significant sulfide mineral oxidation in the investigated spontaneously combusting mine spoils (SCMS). It is likely that the surfacially occurring elemental S was derived from the deeper waste rock layers experiencing spontaneous combustion under limited aeration conditions. The significantly higher acidity, EC and SO_4^{2-} concentration in the SCMS, relative to the non-SCMS suggest that spontaneous combustion is a much faster and more powerful process driving sulfide-derived acid generation, compared to microbially catalysed oxidation of sulfide minerals. The export of acid sulfate materials from the spontaneously combusting waste rock stockpile not only generates severe acid mine drainage but could also act as an inducer for biologically catalysed oxidation of newly exposed sulfide minerals in the areas surrounding the stockpile.

10/01923 Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies

Tamazian, A. and Rao, B. B. *Energy Economics*, 2010, 32, (1), 137–145.
Several studies have examined the relationship between environmental degradation and economic growth. However, most of them did not take into account financial developments and institutional quality. Moreover, Stern noted that there are important econometric weaknesses in the earlier studies, such as endogeneity, heteroscedasticity, omitted variables, etc. The purpose of this paper is to fill this gap in the literature by investigating the linkage between not only economic development and environmental quality but also financial development and institutional quality. The authors employ the standard reduced-form modelling approach to control for country-specific unobserved heterogeneity and GMM estimation to control for endogeneity. This study considers 24 transition economies and panel data for 1993–2004 and the results support the EKC hypothesis while confirming the importance of both institutional quality and financial development for environmental performance. It was also found that financial liberalization may be harmful for environmental quality if it is not accomplished in a strong institutional framework.

10/01924 Economic and environmental assessment on the energetic valorization of organic material for a municipality in Quebec, Canada

Morin, P. *et al. Applied Energy*, 2010, 87, (1), 275–283.
Waste-to-energy provides a solution to two problems: waste management and energy generation. An integrated anaerobic waste valorization process is an interesting option, but because of investments cost and low energy value in the province of Quebec, it is hard for a municipality to commit to that solution. This paper investigated the economic possibilities to manage organic material, organic fraction of municipal solid waste, and municipal wastewater sludge by anaerobic digestion for a 150,000 inhabitant municipality, with consideration to energy generation and greenhouse gas emission reduction. Using the biogas to co-generation solution brings a payback time on investment (PBT) of 3.7 years with electricity price at 0.10 $Cdn/kW h. The addition of manure from surrounding farms increases the biogas production by 37%, but increases the PBT to 6.8 years unless the leftover digestate can be used for agronomic valorization; then it becomes economically advantageous. The natural gas purchasing cost is too low to promote the enrichment of biogas into renewable natural gas. However, this scenario has the lowest energetic payback time (3.3 years) and reduces the most greenhouse gas emissions (4261 tCO_2eq/a).

10/01925 Energy and emission analysis for industrial motors in Malaysia

Saidur, R. *et al. Energy Policy*, 2009, 37, (9), 3650–3658.
The industrial sector is the largest user of energy in Malaysia. Industrial motors account for a major segment of total industrial energy use. Since motors are the principle energy users, different energy savings strategies have been applied to reduce their energy consumption and associated emissions released into the atmosphere. These strategies include using highly efficient motors, variable speed drive (VSD), and capacitor banks to improve the power factor. It has been estimated that there can be a total energy savings of 1765, 2703 and 3605 MWh by utilizing energy-efficient motors for 50%, 75% and 100% loads, respectively. It was also found that for different motor loads, an estimated US$115,936 US$173,019 and US$230,693 can be saved in anticipated energy costs. Similarly, it is hypothesized that a significant amount of energy can be saved using VSD and capacitor banks to reduce speed and improve the power factor, thus cutting energy costs. Moreover, a substantial reduction in the amount of emissions can be effected together with the associated energy savings for different energy savings strategies. In addition, the payback period for different energy savings strategies has been found to be reasonable in some cases.

10/01926 Environmental factors in woodfuel production: opportunities, risks, and criteria and indicators for sustainable practices

Lattimore, B. *et al. Biomass and Bioenergy*, 2009, 33, (10), 1321–1342.
Bioenergy from sustainably managed forest ecosystems could provide a renewable, carbon-neutral source of energy in many nations and communities throughout the world. In order for forest bioenergy to be an ecologically sustainable fuel source, woodfuel procurement systems must not adversely impact forest ecosystems or the environment. Sustainable forest management (SFM) certification schemes are one mechanism for applying standards and monitoring regimes to forest management systems to ensure ecological sustainability. This paper provides a global review of the main environmental risks to forest ecosystems that can arise from household- to industrial-scale woodfuel production systems, including forest soil quality and site productivity, water resources, biodiversity and carbon budgets. A set of regionally adaptable principles, criteria, indicators and verifiers of sustainable forest management were developed, based on criteria and indicators from existing internationally recognized certification frameworks and scientific literature and tailored to address issues relevant to producing and harvesting forest bioenergy feedstocks. A variable monitoring approach and a three-tiered certification approach are proposed as two methods for enabling the adoption of certification and associated monitoring requirements across a wide range of forest operations in regions with widely differing levels of development. The importance of the adaptive forest management framework inherent in certification systems to ensuring the efficacy and continual improvement in woodfuel sustainability is stressed. The proposed principles, criteria, indicators and verifiers can be adapted to local conditions and incorporated into existing sustainable forest management and green energy certification schemes, as well as other criteria and indicator frameworks, to ensure the environmental sustainability of woodfuel production systems.

10/01927 Estimating the effect of urban density on fuel demand

Karathodorou, N. *et al. Energy Economics*, 2010, 32, (1), 86–92.
Much of the empirical literature on fuel demand presents estimates derived from national data which do not permit any explicit consideration of the spatial structure of the economy. Intuitively the degree of spatial concentration of activities would be expected to have a strong link with transport fuel consumption. The present paper addresses this theme by estimating a fuel demand model for urban areas to provide a direct estimate of the elasticity of demand with respect to urban density. Fuel demand per capita is decomposed into car stock per capita, fuel consumption per kilometre and annual distance driven per car per year. Urban density is found to affect fuel consumption, mostly through variations in the car stock and in the distances travelled, rather than through fuel consumption per kilometre.

10/01928 Evaluation of the effectiveness of the regulatory regime in the management of oil pollution in Kenya

Ohowa, B. O. *Ocean & Coastal Management*, 2009, 52, (1), 17–21.
This paper presents an evaluation of the effectiveness of the regulatory regime in the management of oil pollution on Kenya's marine and coastal environment. The prospect of chronic oil pollution along the Kenyan coastline and the port of Mombasa is discussed. A review of the vulnerable marine and coastal resources, commonly used indicators of effectiveness in oil pollution management and the legislation governing oil pollution is given. The author concludes by emphasizing that despite having the right legislation in place, there is need for the establishment of criteria and indicators necessary for evaluation of policy effectiveness.

10/01929 Fuel wood consumption pattern of tribal communities in cold desert of the Lahaul valley, North-Western Himalaya, India

Rawat, Y. S. *et al. Biomass and Bioenergy*, 2009, 33, (11), 1547–1557.
Fuel wood is the primary source of energy in rural areas of the Himalaya. Lack of resources, extremely low temperature and xeric climatic conditions of the study region (Khoksar 3200 m, Jahlma 3000 m, Hinsa 2700 m and Kuthar 2600 m) of cold desert of the Lahaul valley has led to serious deforestation due to excessive use of fuel wood in the past. On the basis of family sizes, fuel wood consumption was recorded less in large family as compared to small family. The fuel wood is used for various activities such as cooking, water heating, room heating, lighting and livestock rearing, etc. Fuel wood consumption was highest in high altitude villages as compared to low altitude villages irrespective of family size. Fuel wood consumption of 4.32 ± 0.99 kg/capita/day was highest at Khoksar for small family during winter season followed by the autumn (2.25 ± 0.15 kg/capita/day) and summer (1.38 ± 0.13 kg/capita/day). The labour energy expenditure for fuel wood collection was also highest for Khoksar (91.91 MJ/capita/year), followed by Hinsa (61.29 MJ/capita/year), Kuthar (52.01 MJ/capita/year) and Jahlma (51.89 MJ/capita/year), respectively. It was found that fuel wood consumption in the study region was influenced by the local cold climate and season of the year. The present information on fuel wood consumption pattern at different altitudes would be helpful in designing appropriate technologies to develop energy plantations in the region.

10/01930 Gas build-up in a domestic property following releases of methane/hydrogen mixtures

Lowesmith, B. J. *et al. International Journal of Hydrogen Energy*, 2009, 34, (14), 5932–5939.

The results of large-scale experiments to study gas accumulation within a ventilated enclosure representing a domestic room are presented. Gas was released vertically upwards at a pressure typical of that experienced in a domestic environment from hole sizes representative of leaks and breaks in pipes. The released gas composition was either methane or a methane/hydrogen mixture containing up to 50% hydrogen. During the experiments, gas concentrations throughout the enclosure and the external wind conditions were monitored. A mathematical model has also been developed to describe the gas release as it mixes with air and forms a layer of gas/air mixture in the upper part of the enclosure. The model accounts for both wind and buoyancy driven ventilation, which arises as a result of the formation of the gas accumulation within the enclosure. The results show the importance of buoyancy driven ventilation on the steady state gas concentrations achieved.

10/01931 GISELA – GIS-based evaluation of land use and agriculture market analysis under global warming

Mori, S. *et al. Applied Energy*, 2010, 87, (1), 236–242.

One of the important future issues is how agriculture production can meet the future demand increase due to the population and the income growth. Global warming would give both positive and negative impacts on them. Agriculture is often expected to supply biofuels to meet the growing transportation energy demand and the warming control policy. GISELA – GIS-based evaluation for land use and agriculture production model – is developed to evaluate the current and the potential cropland for rice, wheat, maize and soy-beans production under climate changes. The authors assess the food and the feed demand based on the historical regional statistics for world into 18 regions. Finally, they assess the future food market integrating the above supply and demand conditions developing a dynamic optimization model, GISELA. Current GISELA findings are as follows: (1) potential cropland in south America will be extensively cultivated, (2) market price of wheat and soy will gradually go up while that of maize is almost stable in medium yield case, and (3) in the low-yield case, all crop prices hike rapidly in the mid of this century.

10/01932 Groundwater remediation by an in situ biobarrier: a bench scale feasibility test for methyl tert-butyl ether and other gasoline compounds

Saponaro, S. *et al. Journal of Hazardous Materials*, 2009, 167, (1–3), 545–552.

Most gasoline contains high percentages of methyl tert-butyl ether (MTBE) as an additive. The physico-chemical properties of this substance (high water solubility, low sorption in soil) result in high mobility and dissolved concentrations in soil. *In situ* permeable biological barriers (biobarriers, BBs) can remediate MTBE polluted groundwater by allowing pure cultures or microbial consortia to degrade MTBE when aerobic conditions are present, either by direct metabolism or cometabolism. Lab-scale batch and column tests were carried out to assess a selected microbial consortium in biodegrading MTBE and other gasoline compounds (benzene B, toluene T, ethylbenzene E, xylenes X) and to measure the parameters affecting the efficacy of a BB treatment of polluted groundwater. During the aerobic phase of the batch tests, the simultaneous biodegradation of MTBE, tert-butyl alcohol (TBA), B, T, E and *o*-X was observed. The rapid biodegradation of BTEXs resulted in decreased oxygen availability, but MTBE degradation was nevertheless measured in the presence of BTEXs. Stationary concentrations of MTBE and TBA were measured when anoxic conditions occurred in the systems. Values for a first order kinetic removal process were obtained for MTBE ($0.031 \pm 0.001\,d^{-1}$), B ($0.045 \pm 0.002\,d^{-1}$) and T ($0.080 \pm 0.004\,d^{-1}$) in the inoculated column tests. The estimate of the BB design parameters suggested that inoculation could significantly modify (double) the longitudinal dispersivity value of the biomass support medium. No effect was observed in the retardation factors for MTBE, B and T.

10/01933 Household energy consumption pattern and socio-cultural dimensions associated with it: a case study of rural Haryana, India

Joon, V. *et al. Biomass and Bioenergy*, 2009, 33, (11), 1509–1512.

A survey of household energy consumption pattern was carried out in a village of Jhajjhar district of Haryana, India in the year 2007. The households surveyed covered heterogeneous population belonging to different income, educational and social groups. There was more availability and utilization of solid biomass fuels as energy resources in domestic sector as compared to the commercial fuels. Dung cakes, crop residues and firewood were found to be the three main fuels used for cooking, though LPG was also used along with biomass fuels. But complete conversion to cleaner fuels has not taken place yet even in households that has been using LPG for many years. Income was an important factor determining the choice of fuel for cooking, but there were some socio-cultural factors which were equally important in making fuel preferences at household level.

10/01934 Hydrogen related risks within a private garage: concentration measurements in a realistic full scale experimental facility

Gupta, S. *et al. International Journal of Hydrogen Energy*, 2009, 34, (14), 5902–5911.

The next generation of hydrogen energy based vehicles is expected to come into widespread use in the near future. Various topics related to hydrogen including, production, storage, and application of hydrogen as an energy carrier, have become subjects of discussion in the framework of various European and international projects. Safety information is vital to support the successful introduction into mainstream and public acceptance of hydrogen as an energy carrier. One of such issues, which is seeking major attention is related to hydrogen powered vehicles parked inside a confined area (such as in a private garage). It is of utmost importance to predict, if uncontrolled release of hydrogen from a vehicle parked inside a confined area can create an explosive atmosphere. Subsequently, how preventive measures can be implied to control these explosive atmospheres, if present inside a confined area? There is little guidance currently developed for confined areas accommodating hydrogen fuelled vehicles. It is essential that mitigation measures for such conditions become established. The present work is developed in the framework of ‘European Network of Excellence HySafe’ and the French national project DRIVE (experimental data for the evaluation of hydrogen risks onboard vehicles, the validation of numerical tools and the edition of guidelines). This paper investigates the possible non-catastrophic scenarios that may arise in a real situation from a hydrogen-fuelled vehicle parked inside a garage. The studied test cases evaluate the influence of injected volumes of hydrogen and the initial conditions at the leakage source on the dispersion and mixing characteristics in an unobstructed confined environment. The mixing process and build-up of hydrogen concentration are measured for the duration of 24 h. Due to safety reasons, helium is used instead of hydrogen.

10/01935 Identifying predictors of attitudes towards local onshore wind development with reference to an English case study

Jones, C. R. and Eiser, J. R. *Energy Policy*, 2009, 37, (11), 4604–4614.

The threats posed by climate change are placing governments under increasing pressure to meet electricity demand from low-carbon sources. In many countries, including the UK, legislation is in place to ensure the continued expansion of renewable energy capacity. Onshore wind turbines are expected to play a key role in achieving these aims. However, despite high levels of public support for onshore wind development in principle, specific projects often experience local opposition. Traditionally this difference in general and specific attitudes has been attributed to NIMBYism (not in my back yard), but evidence is increasingly calling this assumption into question. This study used multiple regression analysis to identify what factors might predict attitudes towards mooted wind development in Sheffield, England. This study reports on the attitudes of two groups; one group (target) living close to four sites earmarked for development and an unaffected comparison group (comparison). The authors found little evidence of NIMBYism amongst members of the target group; instead, differences between general and specific attitudes appeared attributable to uncertainty regarding the proposals. The results are discussed with respect to literature highlighting the importance of early, continued and responsive community involvement in combating local opposition and facilitating the deployment of onshore wind turbines.

10/01936 Impacts of integration of production of black and green energy

Zhou, H. and Tamas, M. M. *Energy Economics*, 2010, 32, (1), 220–226.

As the mandate for minimum renewable sources renders tradable green certificates (TGCs) an essential input for power generation, it may induce mergers between power companies of conventional and renewable sources. Such mergers enable the integrated firms to extend market power from the TGC market to the physical energy market. The authors found that the price of TGCs is indeed higher in the integrated market than the disintegrated market, indicating the presence of market power leveraging. However, despite higher TGC price, the total supply of electricity is greater under integration than disintegration, reflecting efficiency gains from vertical integration, which eliminates double marginalization. The thrust of this paper is that market changes induced by environmental policies will in turn affect environmental and economic regulations. For example, increased supply resulting from integration induced by the renewable source mandate may reduce the effectiveness of programs that promote energy saving behaviour, but at the same time creates room for raising the minimum of renewable sources without unduly depressing production and consumption.

10/01937 Influence of environmental conditions on carbonaceous particle concentrations within New Zealand

Trompetter, W. J. *et al. Journal of Aerosol Science*, 2010, 41, (1), 134–142.

Variables that influence ambient concentrations of air particulate matter due to motor vehicle emissions and biomass burning for home heating were investigated for 10 urban environments in New Zealand. It was found that contributions to ambient particulate matter concentrations from these two main anthropogenic carbonaceous sources were only sometimes correlated with the population and/or source activity within an airshed. The average particulate concentration attributed to motor vehicle emissions was found to correlate with the airshed population, whereas the home heating contribution was observed to be independent. It was found that particulate matter from biomass burning for home heating emissions often build up during cold calm nights under temperature inversion conditions, restricting vertical dispersion thus confining air particulate matter to a limited atmospheric volume. The average winter particulate concentrations due to home heating within the airsheds studied were attributed more to environmental confinement rather than source activity.

10/01938 Is fuel-switching a no-regrets environmental policy? VAR evidence on carbon dioxide emissions, energy consumption and economic performance in Portugal

Pereira, A. M. and Pereira, M. M. *Energy Economics*, 2010, 32, (1), 227–242.

The objective of this paper is to estimate the impact of carbon dioxide emissions from fossil fuel combustion activities on economic activity in Portugal in order to evaluate the economic costs of policies designed to reduce carbon dioxide emissions. The authors found that energy consumption has a significant impact on macroeconomic activity. In fact, a one ton of oil equivalent permanent reduction in aggregate energy consumption reduces output by €6340 over the long term, an aggregate impact which hides a wide diversity of effects for different fuel types. More importantly, and since carbon dioxide emissions are linearly related to the amounts of fuel consumed, the results allow the estimation of the costs of reductions in carbon dioxide emissions from different energy sources. The authors estimate that marginal abatement costs for carbon dioxide are €45.62 per ton of carbon dioxide per year for coal, €66.52 for oil, €91.07 for gas, €191.13 for electricity and €254.23 for biomass. An important policy implication is that, once the overall economic costs of reducing carbon dioxide emissions are considered, fuel switching is a no-regrets environmental policy capable of reducing carbon dioxide emissions without jeopardizing economic activity and indeed with the potential for generating favourable economic outcomes.

10/01939 Lay concepts on CCS deployment in Switzerland based on qualitative interviews

Wallquist, L. *et al. International Journal of Greenhouse Gas Control*, 2009, 3, (5), 652–657.

Laypeople's acceptance and perception of carbon dioxide capture and storage (CCS) can have an influence on its political feasibility. It is important, therefore, to study how laypeople perceive CCS and which cognitions they hold with respect to this technique. The authors conducted in-depth interviews with laypeople ($N = 16$) to explore their mental concepts of CCS. Little knowledge about CCS was detected among laypeople. They also found that laypeople fear that a deployment of CCS could create incentives that would hinder a sustainable development of the energy economy. A misunderstanding of the concepts of hydro- and geostatic pressure, as well as a lack of knowledge about the physical–chemical properties of carbon dioxide seemed to trigger fundamental rejection of CCS among some laypeople. Future research should study which of the concepts and beliefs found in the present study are stable and which of them can be easily corrected by information given to the respondents.

10/01940 Optimization of fuel core loading pattern design in a VVER nuclear power reactors using particle swarm optimization (PSO)

Babazadeh, D. *et al. Annals of Nuclear Energy*, 2009, 36, (7), 923–930.

The two main goals in core fuel loading pattern design optimization are maximizing the core effective multiplication factor (K_{eff}) in order to extract the maximum energy, and keeping the local power peaking factor (P_q) lower than a predetermined value to maintain fuel integrity. In this research, a new strategy based on particle swarm optimization (PSO) algorithm has been developed to optimize the fuel core loading pattern in a typical VVER. The PSO algorithm presents a simple social model by inspiration from bird collective behaviour in finding food. A modified version of PSO algorithm for discrete variables has been developed and implemented successfully for the multi-objective optimization of fuel loading pattern design with constraints of keeping P_q lower than a predetermined value and maximizing K_{eff}. This strategy has been accomplished using WIMSD and CITATION calculation codes. Simulation results show that this algorithm can help in the acquisition of a new pattern without contravention of the constraints.

10/01941 Radiological risk assessment for an urban area: focusing on a drinking water contamination

Jeong, H.-J. *et al. Annals of Nuclear Energy*, 2009, 36, (9), 1313–1318.

This paper specifically discusses a water quality modelling and health risk assessment for cesium-137 to assess the potential and actual effects on human health from drinking water contaminated by a radiological terrorist attack in the Seoul metropolitan area, Korea. With respect to the source term caused by a terrorist attack, it was assumed that 50 TBq of cesium-137 was introduced into the Paldang Lake which is a single water resource for the Seoul metropolitan area. The EFDC (environmental fluid dynamics code) model was used to calculate the hydrodynamic and water quality for the model domain, Paldang Lake. Mortality risk and morbid risk coefficients caused by the ingestion of tap water were used to assess a human health risk due to cesium-137. The transport of cesium-137 in the Paldang water system was mainly dependent on the flow streamlines and the effect of the dilution from the other branches. The mortality and morbidity risks due to the drinking water contamination by cesium-137 were 4.77×10^{-7} and 6.92×10^{-7}, respectively. Accordingly, it is very important to take appropriate countermeasures when radiological terrorist attacks have occurred at water resources to prevent radiological risks by radionuclides.

10/01942 Research on the waiting time of passengers and escalator energy consumption at the railway station

Ma, W.-W. *et al. Energy and Buildings*, 2009, 41, (12), 1313–1318.

Based on the Little formula and the classical queuing model of multichannel $M|D|n$, the relations of the average queue length, the maximum waiting time and the escalator service intensity were identified and the waiting time simulation model was established. With the passenger delivery data at a railway station in China and the probability distribution model of waiting time, a detailed analysis was made on the escalator allocation, power and energy consumption on holidays, ordinary working days and the largest-passengers-volume days; meanwhile, the fixed and variable energy consumption were compared and studied when the waiting time are 5, 10 and 30 s. The result shows that the waiting time settings affect the allocation and the energy consumption of the escalators and the fixed energy consumption takes 70%.

10/01943 Studies of lagoon ash from Sarawak to assess the impact on the environment

Kolay, P. K. and Singh, H. *Fuel*, 2010, 89, (2), 346–351.

Coal utilization, mainly in thermal power plants, has increased significantly from 4.2 to 13 million tonnes within 2000 to 2005, which resulted in the production of approximately 2 million tonnes of coal ash in Malaysia. Of this only a small percentage is used as a cement ingredient, in concrete industry, as a fill material, etc. and with the rest of the amount being disposed in ash ponds or lagoons. If the lagoons are not properly designed with a landfill liner or if there is spillage from the ash pond, the toxic heavy metal present in coal ash can result in the contamination of the subsurface soil and the ground water. The concentration of heavy metals or trace elements in coal residues depends on the composition of a particular parent coal and the bulk utilization of lagoon ash for various purposes requires a complete characterization of the ash. Hence, this paper analyses the coal ash for its trace element content and characterizes mainly physical, chemical, mineralogical, morphological and thermal properties of the lagoon ash from a local coal based thermal power plant from Sarawak, Malaysia. The results also indicated that, the concentration of some trace elements is quite high from the environmental perspective in this particular lagoon ash.

10/01944 The impact of household consumption patterns on emissions in Spain

Duarte, R. *et al. Energy Economics*, 2010, 32, (1), 176–185.

This paper analyses the relationship between household consumption patterns and pollution in the Spanish economy. The analysis was carried using a social accounting matrix (SAM) for the Spanish economy prepared for 1999. Taking the final demand of households as the exogenous account in the SAM framework and combining this with the information provided by the 'Household Budget Continuous Survey' on income and consumption, the authors analyse the pollution produced by both the economy and households in order to satisfy consumption requirements. The effects of income inequality on expenditure levels, establishing a link between income level, consumption patterns, propensity to consume and CO_2 emissions are also considered.

10/01945 Uncertainty in the learning rates of energy technologies: an experiment in a global multi-regional energy system model

Rout, U. K. *et al. Energy Policy*, 2009, 37, (11), 4927–4942.

The diffusion of promising energy technologies in the market depends on their future energy production–cost development. When analysing these technologies in an integrated assessment model using endogenous technological learning, the uncertainty in the assumed learning rates (LRs) plays a crucial role in the production–cost development and model outcomes. This study examines the uncertainty in LRs of some energy technologies under endogenous global learning implementation and presents a floor-cost modelling procedure to systematically regulate the uncertainty in LRs of energy technologies. The article narrates the difficulties of data assimilation, as compatible with mixed integer programming segmentations, and comprehensively presents the causes of uncertainty in LRs. This work is executed using a multi-regional and long-horizon energy system model based on 'TIMES' framework. All regions receive an economic advantage to learn in a common domain, and resource-ample regions obtain a marginal advantage for better exploitation of the learning technologies, due to a lower supply-side fuel-cost development. The lowest learning investment associated with the maximum LR mobilizes more deployment of the learning technologies. The uncertainty in LRs has an impact on the diffusion of energy technologies tested, and therefore this study scrutinizes the role of policy support for some of the technologies investigated.

10/01946 Universalization of access to modern energy services in Indian households – economic and policy analysis

Reddy, C. R. and Eiser, B. S. *Energy Policy*, 2009, 37, (11), 4645–4657.

Provision of modern energy services for cooking (with gaseous fuels) and lighting (with electricity) is an essential component of any policy aiming to address health, education or welfare issues; yet it gets little attention from policy-makers. Secure, adequate, low-cost energy of quality and convenience is core to the delivery of these services. The present study analyses the energy consumption pattern of Indian domestic sector and examines the urban-rural divide and income energy linkage. A comprehensive analysis is done to estimate the cost for providing modern energy services to everyone by 2030. A public-private partnership-driven business model, with entrepreneurship at the core, is developed with institutional, financing and pricing mechanisms for diffusion of energy services. This approach, termed as EMPOWERS (entrepreneurship model for provision of wholesome energy-related basic services), if adopted, can facilitate large-scale dissemination of energy-efficient and renewable technologies like small-scale biogas/biofuel plants, and distributed power generation technologies to provide clean, safe, reliable and sustainable energy to rural households and urban poor. It is expected to integrate the processes of market transformation and entrepreneurship development involving government, NGOs, financial institutions and community groups as stakeholders.

10/01947 Water: a key resource in energy production

Carrillo, A. M. R. and Frei, C. *Energy Policy*, 2009, 37, (11), 4303–4312.

Water and energy are the key resources required for both economic and population growth, and yet both are increasingly scarce. The distribution of water takes large amounts of energy, while the production of energy requires large amounts of water in processes such as thermal plant cooling systems or raw materials extraction. This study analyses the water needs for energy production in Spain according to the energy source sector (electricity, transportation or domestic) and process type (extraction and refining of raw materials or thermal plant use). Current and future water needs are quantified according to energy demand and technology mix evolution. Hypothetical scenarios that simulate the risks of promoting specific energy policies are also analysed. Results show that the combination of energy resources used in Spain is projected to be more than 25% more water consumptive in 2030 than in 2005 under ceteris paribus conditions. Renewable energies are mixed in terms of their consequences on the water supply; wind power can reduce water withdrawal, while the biofuels production is a water-intensive process.

CO_2, NO_x, SO_2 and particulate emissions

10/01948 Allocating the CO_2 emissions of an oil refinery with Aumann–Shapley prices: comment

Moghaddam, A. T. N. *Energy Economics*, 2010, 32, (1), 243–255.

The allocation of CO_2 emissions of petroleum refineries to their oil products is a necessary step in the retrospective well-to-tank (WTT) analysis. These allocated emissions are used to evaluate the environmental impacts of automotive fuels' production within the refinery. Oil refining is a complex joint production system and there exists no simple and unique answer to this allocation question. Recently, Pierru proposed adapting the Aumann–Shapley cost sharing method to deal with this issue. This paper aims at describing the conceptual and technical difficulties of this adaptation to the WTT context. Moreover, the authors show that this approach, as proposed by Pierru, is not applicable to any real-type refinery model. Different suggestions are provided to improve its applicability (when it is possible) in real situations. A simple numerical example as well as a real-type refinery case study is provided for illustrations. Finally, an alternative allocation approach is discussed which the authors believe is more adapted to the WTT context.

10/01949 Design issues in a mandatory greenhouse gas emissions registry for the United States

Stolaroff, J. K. *et al. Energy Policy*, 2009, 37, (9), 3463–3466.

On 10 March 2009, the US Environmental Protection Agency (EPA) proposed a new rule, mandatory reporting of greenhouse gases (GHGs). When final, the rule would compel most large sources of GHGs to report their emissions to EPA as well as fossil fuel suppliers and vehicle engine manufacturers to report their fuel sales and engine emissions rates, respectively. The authors suggest a number of improvements to the rule that would enhance compatibility with expected future climate legislation and enable a broader range of policies and analysis: (1) lower the threshold for reporting to a level more consistent with expected future legislation, (2) require reporting of electricity use along with direct emissions, (3) require reporting of emissions per unit output for a small number of selected sectors, (4) include a system of identifying corporate ownership of reporting facilities, and (5) identify a path toward coverage for sectors that were left out of the proposal due to underdeveloped reporting protocols.

10/01950 Greenhouse gas emission factor development for coal-fired power plants in Korea

Jeon, E.-C. *et al. Applied Energy*, 2010, 87, (1), 205–210.

Accurate estimation of greenhouse gas emissions is essential for developing an appropriate strategy to mitigate global warming. This study examined the characteristics of greenhouse gas emission from power plants, a major greenhouse gas source in Korea. The power plants examined use bituminous coal, anthracite, and sub-bituminous coal as fuel. The CO_2 concentration from power plants was measured using GC–FID with methanizer. The amount of carbon, hydrogen, and calorific values in the input fuel was measured using an elemental analyser and calorimeter. For fuel analysis, CO_2 emission factors for anthracite, bituminous coal, and sub-bituminous coal were 108.9, 88.4, and 97.9 Mg/kJ, respectively. The emission factors developed in this study were compared with those for IPCC. The results showed that CO_2 emission was 10.8% higher for anthracite, 5.5% lower for bituminous coal, and 1.9% higher for sub-bituminous coal than the IPCC figures.

10/01951 Greenhouse gas emissions in Hawaii: household and visitor expenditure analysis

Konan, D. E. and Chan, H. L. *Energy Economics*, 2010, 32, (1), 210–219.

This paper focuses on petroleum use and greenhouse gas emissions associated with economic activities in Hawaii. Data on economic activity, petroleum consumption by type (gasoline, diesel, aviation fuel, residual, propane), and emissions factors are compiled and analysed. In the baseline year 1997, emissions are estimated to total approximately 23.2 million metric tons of carbon, 181 thousand metric tons of nitrous oxide, and 31 thousand metric tons of methane in terms of carbon-equivalent global warming potential over a 100-year horizon. Air transportation, electricity, and other transportation are the key economic activity responsible for GHG emissions associated with fossil fuel use. More than 22% of total emissions are attributed to visitor expenditures. On a per person per annum basis, emission rates generated by visitor demand are estimated to be higher than that of residents by a factor of 4.3 for carbon, 3.2 for methane, and 4.8 for nitrous oxide.

10/01952 Impact of a possible environmental externalities internalisation on energy prices: the case of the greenhouse gases from the Greek electricity sector

Georgakellos, D. A. *Energy Economics*, 2010, 32, (1), 202–209.

This paper is concerned with the impact of the internalization of environmental externalities on energy prices. In this context, its aim is to quantify the external cost of greenhouse gases (specifically carbon dioxide) generated during electricity production in the thermal power plants in Greece and to estimate the impact on the electricity production cost and on the electricity prices of a possible internalization of this external cost by the producers. For this purpose, this paper applies the EcoSenseLE online tool to quantify the examined externalities. This research finds that the calculated external cost is significantly high (compared to the corresponding production cost) mainly in lignite-fired power plants. Specifically, a possible internalization of this external cost would increase the production cost by more than 52% (on average), which, in turn, would affect similarly the electricity prices. This finding could be important for decision makers in the electricity sector to develop strategies for emission reduction and to develop environmental and energy policies. The general limitation of the external cost methodology applies to this work as it uses the standard method developed for the Externe project. Similarly, the data limitations as well as assumptions related to the costs and exclusions/omissions of cost elements affect the results.

10/01953 Interventions for large-scale carbon emission reductions in future UK offices

Jenkins, D. P. *et al. Energy and Buildings*, 2009, 41, (12), 1374–1380.
Previous work by the authors has shown the effect that changing climate and small power/lighting equipment can have on heating and cooling loads of typical existing UK offices, for a 2005 baseline. This follow-on study uses an improved office, with reduced cooling loads, and performs retrofit fabric and HVAC measures to further reduce the energy and associated CO_2 emissions. The effect of heat recovery on the proposed '2030 office' is then quantified, showing that such an office can tend towards being 'passively heated'. With adaptive comfort also applied, the office CO_2 emissions are estimated for various UK locations. The measures suggest CO_2 emissions relating to heating, cooling and ventilation (HVAC) can be reduced by 61% for the specific office-type studied. The proposed measures are carried out while allowing for a change in activity between 2005 and 2030. When all factors leading to changes in energy use are accounted for, namely small power, lighting, HVAC and climate change, total CO_2 savings of 65% are estimated when compared to the 2005 baseline. In achieving these theoretical savings, the relationship between internal activity and HVAC is studied, and identified as being a crucial area if challenging CO_2 emission targets are to be reached.

10/01954 Prediction of SO_2 removal efficiency for wet flue gas desulfurization

Dou, B. *et al. Energy Conversion and Management*, 2009, 50, (10), 2547–2553.
The wet flue gas desulfurization in the coal-fired power plants has been the most widely used because of its high SO_2 removal efficiency, reliable and low utility consumption. The difficulty in the prediction of the SO_2 removal from flue gas is that the performance of the system is related to a wide range of variables. In this paper, the SO_2 was removed by absorbing and reacting SO_2 with limestone slurry, and limestone scrubbing was accomplished in a spraying reactor. Experimental investigations for effects of different operating variables on the SO_2 removal showed the reasonable process parameters such as the pH value of the liquid phase, droplet size of the spray and the flow rates of liquid and gas. The removal process was analysed using the two-film theory of mass-transfer. Both the liquid and gas side resistances were important, and the absorption rate was controlled by a combination of both gas-film and liquid-film diffusion controls. A model of external mass-transfer with the effects of a chemical enhancement factor and sulfite concentration in the liquid phase was developed for the prediction of the SO_2 removal efficiency, and the calculated values were in reasonable agreement with the experimental values. The study is considered as the one-dimensional prediction of SO_2 removal and low-cost application of limestone slurry for commercial FGD technology.

10/01955 Structural decomposition analysis of Australia's greenhouse gas emissions

Wood, R. *Energy Policy*, 2009, 37, (11), 4943–4948.
A complex system of production links greenhouse gas emissions to consumer demands. While progress may be made in improving efficiency, other changes in the production structure may easily annul global improvements. Utilizing a structural decomposition analysis, a comparative-static technique of input–output analysis, over a time period of around 30 years, net greenhouse emissions are decomposed in this study into the effects, due to changes in industrial efficiency, forward linkages, inter-industry structure, backward linkages, type of final demand, cause of final demand, population affluence, population size, and mix and level of exports. Historically, significant competing forces at both the whole of economy and industrial scale have been mitigating potential improvements. Key sectors and structural influences are identified that have historically shown the greatest potential for change, and would likely have the greatest net impact. Results clearly reinforce that the current dichotomy of growth and exports are the key problems in need of address.

10/01956 Total factor carbon emission performance: a Malmquist index analysis

Zhou, P. *et al. Energy Economics*, 2010, 32, (1), 194–201.
This paper introduces a Malmquist CO_2 emission performance index (MCPI) for measuring changes in total factor carbon emission performance over time. The MCPI is derived by solving several data envelopment analysis models. Bootstrapping MCPI is proposed to perform statistical inferences on the MCPI results. Using the index the emission performance of the world's 18 top CO_2 emitters from 1997 to 2004 is studied. The results obtained show that the total factor carbon emission performance of the countries as a whole improved by 24% over the period and this was mainly driven by technological progress. The results of a cross-country regression analysis to investigate the determinants of the resulting MCPI are presented.

10/01957 Transport sector CO_2 emissions growth in Asia: underlying factors and policy options

Timilsina, C. R. and Shrestha, A. *Energy Policy*, 2009, 37, (11), 4523–4539.
This study analyses the potential factors influencing the growth of transport sector carbon dioxide (CO_2) emissions in selected Asian countries during the 1980–2005 period by decomposing annual emissions growth into components representing changes in fuel mix, modal shift, per capita gross domestic product (GDP) and population, as well as changes in emission coefficients and transportation energy intensity. It was found that changes in per capita GDP, population growth and transportation energy intensity are the main factors driving transport sector CO_2 emission growth in the countries considered. While growth in per capita income and population are responsible for the increasing trend of transport sector CO_2 emissions in China, India, Indonesia, Republic of Korea, Malaysia, Pakistan, Sri Lanka and Thailand; the decline of transportation energy intensity is driving CO_2 emissions down in Mongolia. Per capita GDP, population and transportation energy intensity effects are all found responsible for transport sector CO_2 emissions growth in Bangladesh, the Philippines and Vietnam. The study also reviews existing government policies to limit CO_2 emissions growth, such as fiscal instruments, fuel economy standards and policies to encourage switching to less emission intensive fuels and transportation modes.

10/01958 Which is the preferable transport fuel on a greenhouse gas basis; biomethane or ethanol?

Power, N. M. and Murphy, J. D. *Biomass and Bioenergy*, 2009, 33, (10), 1403–1412.
Biomethane and ethanol are both biofuels which are generated from agricultural crops that can be utilized to meet the biofuels directive. In Ireland with the demise of the sugar industry 48,000 ha of land is readily available for biofuel production, without unduly effecting food production. Which biofuel should dominate? This paper investigates biofuel production for three different crop rotations: wheat, barley and sugar beet; wheat, wheat and sugar beet; wheat only. A greenhouse gas balance is performed to determine under what conditions each biofuel is preferable. For both biofuels, the preferred crop on a weight basis is wheat, while on an area basis the preferred crop is sugar beet. Biomethane scenarios produce more gross energy than ethanol scenarios. Under the base assumption (7.41% biogas losses, and biomethane utilized in a converted petrol engine, such as a bi-fuel car, and thus underperforming on a km/MJ basis) ethanol generated more net greenhouse gas savings than biomethane. This was unexpected as biomethane produces twice the net energy per hectare as ethanol. If either biogas losses were reduced or biomethane was utilized in a vehicular engine optimized for biomethane (such as a bus powered solely on gaseous biofuel) then biomethane would generate significantly more net greenhouse gas savings than ethanol. It was found that if biogas losses were eliminated and the biomethane was used in a vehicle optimized for biomethane, then the net greenhouse gas savings are 2.4 times greater than those from ethanol generated from the same feedstock.

Hydrocarbon emissions

10/01959 Effects of anthropopressure and soil properties on the accumulation of polycyclic aromatic hydrocarbons in the upper layer of soils in selected regions of Poland

Maliszewska-Kordybach, B. *et al. Applied Geochemistry*, 2009, 24, (10), 1918–1926.
Fifty soil samples collected from agricultural land in four regions of Poland with different anthropopressure were analysed for their content of 16 polycyclic aromatic hydrocarbons (PAHs) by GC/MS. The regions correspond to Polish administrative units (voievodeships): Podlaskie and Lubelskie are situated in the rural East part of the country and more industrialized Slaskie and Dolnoslaskie voievodeships – in the South-West part. Basic physicochemical properties as well as the content of selected potentially harmful metals (Pb and Zn) were included in the soil analysis. Overall accumulation of Σ16PAHs in the upper soil layer was within the range 73–1800 $\mu g\,kg^{-1}$ with a geometric mean (GM) of 252 $\mu g\,kg^{-1}$, while the mean benzo(a)pyrene (BaP) load was 20 $\mu g\,kg^{-1}$. This corresponds with data for other European

countries. Carcinogenic compounds contributed nearly in 50% to the total PAHs loads. In uncontaminated rural regions the mean Σ16PAHs and BaP contents were 113–159 $\mu g\,kg^{-1}$ and 11–13 $\mu g\,kg^{-1}$, respectively. Regional conditions strongly influenced the accumulation of PAHs $\geq$4-rings, which were highly dependent (over 95%) on local anthropopressure expressed as dust and 4PAHs emission indexes. Soil acidity was the main soil parameter related to the accumulation of higher molecular weight PAHs in soils. In more contaminated regions a significant link between soil OM and PAH loads was noted. The same regions were characterized by associations between PAHs and potentially harmful metals implying common sources of pollution. Those relationships were not observed in the uncontaminated part of the country. The lower molecular weight PAHs contributed to a smaller extent (about 20%) to the total PAHs content in soils, and were less affected by anthropogenic factors.

10/01960 The effect of adding dimethyl carbonate (DMC) and ethanol to unleaded gasoline on exhaust emission

Wen, L. *et al. Applied Energy*, 2010, 87, (1), 115–121.

Oxygen containing additives are usually used to improve gasoline's performance and reduce exhaust emissions. In this study, the effect of oxygen containing additives on gasoline blended fuels on exhaust emissions was investigated for different engine speeds in a single cylinder, four-stroke, spark-ignition engine. The results indicate that CO and HC exhaust emissions are lower with the use of ethanol–gasoline and DMC–gasoline blended fuels as compared to the use of unleaded gasoline. On the other hand, the effect of ethanol–gasoline and DMC–gasoline blended fuels on NO_X exhaust emission is insignificant. Using oxygen containing additives can increase fuel consumption as a result of the heating value of the blended fuels being lower than that of unleaded gasoline.

Life cycle analysis

10/01961 A life cycle analysis on a Bio-DME production system considering the species of biomass feedstock in Japan and Papua New Guinea

Higo, M. and Dowaki, K. *Applied Energy*, 2010, 87, (1), 58–67.

This paper describes the performance and/or CO_2 intensities of a Bio-DME (biomass di-methyl ether) production system, considering the differences of biomass feedstock. In the past LCA studies on an energy chain model, there is little knowledge on the differences of biomass feedstock and/or available condition. Thus, in this paper, the authors selected Papua New Guinea (PNG) which has good potential for supply of an energy crop (a short rotation forestry), and Japan where wood remnants are available, as model areas. Also, they referred to nine species of biomass feedstock of PNG, and to eight species in Japan. The system boundary on this LCA consists of (1) the pre-treatment process, (2) the energy conversion process, and (3) the fuel transportation process. Especially, since the pre-treatment process has uncertainties related to the moisture content of biomass feedstock, as well as the distance from the cultivation site to the energy plant, there were considered by Monte Carlo simulation. Next, the authors executed the process design of the Bio-DME production system based on the basic experimental results of pyrolysis and char gasification reactions. Due to these experiments, the gas components of pyrolysis and the gasification rate under H_2O (steam) and CO_2 were obtained. Also, the pressurized fluid-bed gasification process was designed. In a liquefaction process, that is, a synthesis process of DME, the result based on an equilibrium constant was used. In the proposed system, a steam turbine for an auxiliary power was assumed to be equipped, too. The energy efficiencies are 39.0–56.8 LHV-%, depending upon the biomass species. Consequently, CO_2 intensities in the whole system were 16.3–47.2 g-CO_2/MJ-DME in the Japan case, and 12.2–36.7 g-CO_2/MJ-DME in the PNG one, respectively. Finally, using the results of CO_2 intensities and energy efficiencies, the authors obtained the regression equations as parameters of hydrogen content and heating value of a feedstock. These equations will be extremely significant when the BTL (biomass-to-liquid, e.g. Bio-DME) energy system is installed in the near future, in order to mitigate CO_2 emissions effectively, and to estimate the energy's efficiency.

10/01962 Crop residues as raw materials for biorefinery systems – a LCA case study

Cherubini, F. and Ulgiati, S. *Applied Energy*, 2010, 87, (1), 47–57.

This paper focuses on a biorefinery concept which produces bio-ethanol, bioenergy and biochemicals from two types of agricultural residues, corn stover and wheat straw. These biorefinery systems are investigated using a life cycle assessment (LCA) approach, which takes into account all the input and output flows occurring along the production chain. This approach can be applied to almost all the other patterns that convert lignocellulosic residues into bioenergy and biochemicals. The analysis elaborates on land use change aspects, i.e. the effects of crop residue removal (like decrease in grain yields, change in soil N_2O emissions and decrease of soil organic carbon). The biorefinery systems are compared with the respective fossil reference systems producing the same amount of products/services from fossils instead of biomass. Since climate change mitigation and energy security are the two most important driving forces for biorefinery development, the assessment focuses on greenhouse gas (GHG) emissions and cumulative primary energy demand, but other environmental categories are evaluated as well. Results show that the use of crop residues in a biorefinery saves GHG emissions and reduces fossil energy demand. For instance, GHG emissions are reduced by about 50% and more than 80% of non-renewable energy is saved. Land use change effects have a strong influence in the final GHG balance (about 50%), and their uncertainty is discussed in a sensitivity analysis. Concerning the investigation of the other impact categories, biorefinery systems have higher eutrophication potential than fossil reference systems. Based on these results, a residues-based biorefinery concept is able to solve two problems at the same time, namely find a use for the abundant lignocellulosic residues and ensure a mitigation effect for most of the environmental concerns related to the utilization of non-renewable energy resources. Therefore, when agricultural residues are used as feedstocks, best management practices and harvest rates need to be carefully established. In fact, rotation, tillage, fertilization management, soil properties and climate can play an important role in the determination of the amount of crop residue that can be removed minimizing soil carbon losses.

10/01963 Life cycle assessment (LCA) of waste management strategies: landfilling, sorting plant and incineration

Cherubini, F. *et al. Energy*, 2009, 34, (12), 2116–2123.

This paper focuses on a life cycle assessment (LCA) of four waste management strategies: landfill without biogas utilization; landfill with biogas combustion to generate electricity; sorting plant which splits the inorganic waste fraction (used to produce electricity via refuse derived fuels) from the organic waste fraction (used to produce biogas via anaerobic digestion); direct incineration of waste. These scenarios are applied to the waste amount and composition of the municipality of Rome in Italy and are evaluated under different points of view: global and local emissions, total material demands, total energy requirements and ecological footprints. Results, reliable for most of the European big cities, show landfill systems as the worst waste management options and significant environmental savings at global scale are achieved from undertaking energy recycling. Furthermore, waste treatments finalized to energy recovery provide an energy output that, in the best case, is able to meet the 15% of Rome's electricity consumption.

10/01964 Life cycle assessment and life cycle costing of bioethanol from sugarcane in Brazil

Luo, L. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (6–7), 1613–1619.

Brazil has always been the pioneer in the application of bioethanol as a main fuel for automobiles, hence environmental and economic analyses of the Brazilian ethanol industries are of crucial importance. This study presents a comparative life cycle assessment on gasoline and ethanol as fuels, and with two types of blends of gasoline with bioethanol, all used in a midsize car. The focus is on a main application in Brazil, sugarcane based ethanol. The results of two cases are presented: base case – bioethanol production from sugarcane and electricity generation from bagasse; future case – bioethanol production from both sugarcane and bagasse and electricity generation from wastes. In both cases sugar is co-produced. The life cycles of fuels include gasoline production, agricultural production of sugarcane, ethanol production, sugar and electricity co-production, blending ethanol with gasoline to produce E10 (10% of ethanol) and E85 (85%), and finally the use of gasoline, E10, E85 and pure ethanol. Furthermore, a life cycle costing (LCC) was conducted to give an indication on fuel economy in both cases. The results show that in the base case less GHG is emitted; while the overall evaluation of these fuel options depends on the importance attached to different impacts. The future case is certainly more economically attractive, which has been the driving force for development in the ethanol industry in Brazil. Nevertheless, the outcomes depend very much on the assumed price for crude oil. In LCC a steady-state cost model was used and only the production cost was taken into account. In the real market the prices of fuels are very much dependent on the taxes and subsidies. Technological development can help in lowering both the environmental impact and the prices of the ethanol fuels.

10/01965 Life cycle energy assessment of a typical office building in Thailand

Kofoworola, O. F. and Gheewala, S. H. *Energy and Buildings*, 2009, 41, (10), 1076–1083.

A typical office building in Thailand was analysed using the life cycle energy analysis (LCEA) method. Results indicate that although life cycle energy (LCE) distribution is concentrated at the operating phase, the embodied energy of buildings is a non-negligible fraction of the LCE balance. Energy (electricity) used for lighting and HVAC systems in the operation phase and the manufacture of concrete and steel were the most significant elements in the building's life cycle. Application of a combination of energy saving measures, showed that 40–50% of energy (electricity) used in a typical office building in Thailand can be saved. Preliminary analysis indicated that recycling building materials can contribute additional energy savings (about 8.9%) to a building's LCE profile. Therefore reducing energy consumption should be a priority for not only the operation but also other life cycle phases. It is suggested that both embodied and operating energy should be accounted for within the context of energy efficiency through the incorporation of LCEA into the existing Thai building energy code.

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Supplies, policy, economics, forecasts

10/01966 A comparative study on the energy policies in Japan and Malaysia in fulfilling their nations' obligations towards the Kyoto Protocol

Lau, L. C. *et al. Energy Policy*, 2009, 37, (11), 4771–4778.

Global warming and the associated changes in the world climate pattern have been accepted world wide as the gravest threat to humanity in the twentieth century. To mitigate the impacts of global warming, the Kyoto Protocol was established in 1997 with the objective of reducing global greenhouse gases (GHGs) emission, in particular carbon dioxide, by 5.2% below 1990 levels. Developed nations that ratified the Protocol are committed to GHG reduction targets while developing nations are encouraged to reduce GHG emissions on a voluntary basis. Since most of the GHGs emissions come from the energy sector, energy policy plays an important role in fulfilling the Kyoto Protocol obligations. This year marks the beginning of the commitment period for the 2012 Kyoto Protocol. In this case, it would be worthwhile to compare the energy policies in Malaysia and Japan as these nations move towards fulfilling their obligations towards the Kyoto Protocol; bearing in mind that both countries ratified the Protocol, but that Japan commits a reduction target of 6% while Malaysia bears no obligation. Based on the comparison, recommendations were made on how a developing nation like Malaysia could adopt the policies implemented in Japan to suit local conditions and contribute significantly to GHG reduction.

10/01967 A semiparametric model of household gasoline demand

Wadud, Z. *et al. Energy Economics*, 2010, 32, (1), 93–101.

Gasoline demand studies typically generate a single price and income elasticity for a country. It is however possible that these elasticities may differ among various socio-economic groups. At the same time, parametric gasoline demand models may not be flexible enough to capture the changes in price elasticities with different levels of income. This paper models US gasoline demand using more flexible semiparametric techniques, accommodating the possibility of differences in responses among households. The econometric model employs a non-parametric bivariate smoothing for price and income and a parametric representation of other explanatory variables. Possible heterogeneity in price and income elasticities is modelled through interacting price and income with demographic variables. Results show that price responses do vary with demographic variables such as income, multiple vehicle holding, presence of multiple wage earners or rural or urban residential locations. Households' responses to a price change decrease with higher income. Multiple vehicle and multiple earner households also show higher sensitivity to a price change. Households located in urban areas reduce consumption more than those in rural areas in response to an increase in price. Comparison of the flexible semiparametric model with a parametric translog model, however, reveals no significant differences between results, and the parametric models have the advantage of lower computational requirements and better interpretability.

10/01968 A study on the energy penalty of various air-side system faults in buildings

Lee, S. H. and Yik, F. W. H. *Energy and Buildings*, 2010, 42, (1), 2–10.

Automatic fault detection and diagnosis (FDD) can help enhance building energy efficiency by facilitating early detection of occurrence of system faults, especially those of air-conditioning systems, thus enabling rectification of the faults before much energy is wasted due to such faults. However, building owners may not invest in FDD unless they are convinced of the energy cost savings that can be achieved. This paper presents the results of a study on the energy cost impacts of a range of common system faults in variable air volume (VAV) air-conditioning systems, which are widely adopted for their good part-load energy efficiency. The simulation results indicate that some faults may significantly increase energy use in buildings, for example, negative room air temperature sensor offset, stuck open VAV box damper, negative supply air temperature sensor offset, stuck open outdoor air damper and stuck open and leaking cooling coil valve. Since building occupants may adapt to the symptoms of these faults, such as reduced room air temperature, and thus may not complain about them, the occurrence of such faults are not immediately apparent unless a FDD system is available. Some other faults, e.g. positive supply air temperature sensor offset, positive room air temperature sensor offset, stuck closed cooling coil valve and stuck closed VAV box damper, may allow less energy to be used but will lead to unbearable indoor environmental conditions, such as high indoor temperature. Such faults, therefore, can easily be detected even without a FDD system, as there will be feedback from the building occupants.

10/01969 Account for sector heterogeneity in China's energy consumption: sector price indices vs. GDP deflator

Ma, C. *Energy Economics*, 2010, 32, (1), 24–29.

A common practice in decomposition analyses is to deflate output indicators to purge the impact of inflation by using a general deflator. This practice fails to account for sector heterogeneity and can be hazardous. Although the general identified patterns are largely correct, the calculated magnitudes can be misleading or even wrongly signed. Instead, it is strongly recommended that sector heterogeneity is accounted for by using individual sector price indices for all relevant sectors instead of one general (GDP) deflator. This paper analyses this advanced decomposition using Chinese data and compares to the usual method of using only one deflator. It is found that while most differences are only of quantitative quality, some show even a qualitative difference. Furthermore, the rising energy intensity in the early 2000s, which has been discussed by previous studies, vanishes completely.

10/01970 An energy-economic scenario analysis of alternative fuels for personal transport using the Global Multi-regional MARKAL model (GMM)

Gül, T. *et al. Energy*, 2009, 34, (10), 1423–1437.

This paper deals with the long-term prospects of alternative fuels in global personal transport. It aims at assessing key drivers and key bottlenecks for their deployment, focusing particularly on the role of biofuels and hydrogen in meeting climate policy objectives. The analysis is pursued using the global multi-regional MARKAL model (GMM), a perfect foresight 'bottom-up' model of the global energy system with a detailed representation of alternative fuel chains, linked to the model for the assessment of greenhouse gas induced climate change (MAGICC). The analysis shows that biofuels are limited by the regional availability of low-cost biomass, but can be important for meeting mild climate policy targets. If policy-makers intend to pursue more stringent climate policy, then hydrogen becomes a competitive option. However, the analysis finds that the use of hydrogen in personal transport is restricted to very stringent climate policy, as only such policy provides enough incentive to build up the required delivery infrastructure. An analysis of costs additionally shows that 'keeping the hydrogen option open' does not take considerable investments compared to the investment needs in the power sector within the next decades, but allows the use of hydrogen for the pursuit of stringent climate policy in the second half of the century.

10/01971 An integrated approach to energy prospects for North America and the rest of the world

Bassi, A. M. *et al. Energy Economics*, 2010, 32, (1), 30–42.

Many international organizations and research institutions have released recently unequivocal scenarios on energy's future prospects. The peak in global oil production is likely to happen in the next 10–15 years, and is likely to have large impacts on our quality of life in the coming decades. This study presents an integrated tool for national energy planning customized to North America. The authors analysed the impact of world oil production on economic, social and environmental indicators. Two cases of global ultimate recoverable oil reserves are considered, a low and medium estimate within current research. Three sets of policy directions were chosen: business as usual (market based), maximum push for renewables, and low carbon emissions. Results of the simulations show that without restrictions on emissions coal becomes the dominant energy in the longer term. On the other hand, if US policymakers are able to effectively implement the necessary polices, such as a 20% RPS by 2020 and increased CAFE Standards, along with increased energy conservation and efficiency, the medium to longer-term economic impacts of a global peak in oil production can be mitigated, while a sustained reduction in emissions would require a larger effort.

10/01972 Analysis of the efficiency of the Iberian power futures market

Herráiz, Á. C. and Monroy, C. R. *Energy Policy*, 2009, 37, (9), 3566–3579.

Market efficiency is analysed for the Iberian power futures market and other European power markets, as well as other fuel markets through evaluation of ex-post forward risk premium. The equilibrium price from compulsory call auctions for distribution companies within the framework of the Iberian power futures market is not optimal for remuneration purposes as it seems to be slightly upward biased. In the period considered (August 2006–July 2008), monthly futures contracts behave similarly to quarterly contracts. Average risk premiums have been positive in power and natural gas markets but negative in oil and coal markets. Different hypotheses are tested regarding increasing volatility with maturity and regarding forward risk premium variations (decreasing with variance of spot prices during delivery period and increasing with skewness of spot prices during delivery period). Enlarged data sets are recommended for stronger test results. Energy markets tend to show limited levels of market efficiency. Regarding the emerging Iberian power futures market, price efficiency is improved with market development of all the coexistent forward contracting mechanisms and with further integration of European regional electricity markets.

10/01973 China's fuel economy standards for passenger vehicles: rationale, policy process, and impacts

Oliver, H. H. *et al. Energy Policy*, 2009, 37, (11), 4720–4729.

China issued its first fuel economy standards (FES) for light-duty passenger vehicles (LDPV) in September 2004, and the first and second phases of the FES took effective in July 2005 and January 2008, respectively. The stringency of the Chinese FES ranks third globally, following the Japanese and European standards. This study reviews the policy-making background, including the motivations, key players, and the process; and then explains the content and the features of the FES and why there was no compliance flexibility built into it. Next, the authors assess the various aspects of the standard's impact, including fuel economy improvement, technology changes, shift of market composition, and overall fuel savings. Lastly, they comment on the prospect of tightening the existing FES and summarize the complementary policies that have been adopted or may be considered by the Chinese government for further promoting efficient vehicles and reducing transport energy consumption. The Chinese experience is highly relevant for countries that are also experiencing or anticipating rapid growth in personal vehicles, those wishing to moderate an increase in oil demand, or those desirous of vehicle technology upgrades.

10/01974 Defining limits: energy constrained economic growth

Nel, W. P. and van Zyl, G. *Applied Energy*, 2010, 87, (1), 168–177.

The historical and deductive merits for an explicit energy-based economic growth formulation are presented. Parameters in the formulation are successfully calibrated to empirical data and a range of forecasts is made for global economic growth potential to 2050, based on a plausible case of energy availability. The results demonstrate the vital importance of energy security and lead to the conclusion that the current socio-economic paradigm may not be sustainable.

10/01975 Economic impacts of higher oil and gas prices: the role of international trade for Germany

Lutz, C. and Meyer, B. *Energy Economics*, 2009, 31, (6), 882–887.

The analysis concentrates on direct and indirect price increases, induced shifts in international trade and structural changes in the oil importing economies. The paper at hand asks, whether a stabilizing effect via international trade and domestic structural change on the GDP of oil importing countries can be observed, if a permanent oil price increase occurs. At least for Germany, structural change from consumer goods to investment goods industry and an improvement of international competitiveness limit negative impacts of increased energy prices. Analysis is based on the extensive and disaggregated global GINFORS model and the detailed INFORGE model for the German economy.

10/01976 Economical analysis and relation between energy inputs and yield of greenhouse cucumber production in Iran

Mohammadi, A. and Omid, M. *Applied Energy*, 2010, 87, (1), 191–196.

This paper studies the energy balance between the input and the output per unit area for greenhouse cucumber production. For this purpose, the data on 43 cucumber production greenhouses in the Tehran province, Iran, were collected and analysed. The results indicated that a total energy input of 148,836.76 MJ ha^{-1} was consumed for cucumber production. Diesel fuel (with 41.94%) and chemical fertilizers (with 19.69%) were amongst the highest energy inputs for cucumber production. The energy productivity was estimated as 0.80 k MJ^{-1}. The ratio of energy output to energy input was approximately 0.64. Results indicate 10.93% and 89.07% of total energy input was in renewable and non-renewable forms, respectively. The regression results revealed that the contribution of energy inputs on crop yield (except for fertilizers and seeds energies) was significant. The human labour energy had the highest impact (0.35) among the other inputs in greenhouse cucumber production. Econometric analysis indicated that the total cost of production for one hectare of cucumber production was around $33,425.70. Accordingly, the benefit–cost ratio was estimated as 2.58.

10/01977 Energy and water tradeoffs in enhancing food security: a selective international assessment

Mushtaq, S. *et al. Energy Policy*, 2009, 37, (9), 3635–3644.

Rice is the major staple food in most Asian countries. However, with rapidly growing populations, sustained high productivity and yields through improving water productivity is critically important. Increasingly complex energy–agriculture relationships require an in-depth understanding of water and energy tradeoffs. This study contributes to energy and food policies by analysing the complex energy, water and economics dynamics across a selection of major rice growing countries. The results show that tradeoffs exist between yield and energy inputs with high yield attributed to higher levels of energy input. The selected developed countries show higher energy productivity, relative to all other energy inputs, compared to the selected developing counties, owing to enhanced mechanization, on-farm technology and improved farm management. Among all countries, China has the highest water productivity due to water-saving irrigation practices. These practices offer opportunities for developed and developing countries to increase water productivity at the same time taking advantage of economic and energy benefits of reduced pumping. Sustained production from agriculture is vital to food security. Improved irrigation practices can offset environmental footprints in the short run but their large-scale implementation remains an issue. In the long run, investments are needed to buffer the negative impacts of food production on the environment. Investments to boost water productivity and improved energy use efficiency in crop production are two pathways to reduce energy dependency, enhanced natural resource sustainability and ensuring future food security.

10/01978 Energy crop production costs in the EU

Ericsson, K. *et al. Biomass and Bioenergy*, 2009, 33, (11), 1577–1586.

The objective of this study was to calculate indicative ranges of production costs and assess the main sources of cost for a number of energy crops, both annual and perennial, on a regional level in Europe. The production costs were calculated in terms of the economic compensation required by the farmer in order to grow the crop, and therefore include not only the cost of cultivation, but also the costs of land and risk, which are often omitted in production cost calculations. The cost of land was calculated as the opportunity cost based on the production of cereals. Thus, higher food prices lead to higher land costs, which in turn lead to higher energy crop production costs. The analysis was performed for three cases with different assumptions concerning yields and production cost reductions resulting from scale (total cultivation area in the region), and learning effects. The calculated energy crop production costs were found to be consistently lowest for short-rotation coppice (SRC) crops and highest for annual straw crops. The production costs of SRC crops were calculated to be about 4–5 € GJ^{-1} under present conditions and 3–4 € GJ^{-1} under improved future conditions. The production costs for perennial grasses were calculated to be about 6–7 € GJ^{-1} and 5–6 € GJ^{-1} under present and improved future conditions, respectively. The production costs for annual straw crops were estimated to be 6–8 € GJ^{-1} under present conditions with small potential for cost reductions in the future.

10/01979 Energy policy in transport and transport policy

Van Dender, K. *Energy Policy*, 2009, 37, (10), 3854–3862.

Explanations for, and indirect evidence of, imperfections in the market for private passenger vehicle fuel economy suggest there is a reasonable case for combining fuel economy standards and fuel or carbon taxes to contribute to an energy policy that aims to reduce greenhouse gas emissions and improve energy security. Estimates of key elasticities, including the rebound effect, indicate that the positive and negative side-effects of fuel economy measures on transport activities and external costs are limited. However, an energy policy for transport does not replace a transport policy that aims to manage the main transport externalities including congestion and local pollution.

Conventional marginal cost estimates and standard cost-benefit reasoning suggest that policies that address congestion and local pollution likely bring benefits at least as large as those from fuel economy measures. But the large uncertainty on the possible effects of greenhouse gas emissions constitutes a strong challenge for standard cost-benefit reasoning. Emerging results from methods to cope with this uncertainty suggest that policies to stimulate the widespread adoption of low-carbon technologies in transport are justified.

10/01980 Factors impacting district heating companies' decision to provide small house customers with heat

Lygnerud, K. and Peltola-Ojala, P. *Applied Energy*, 2010, 87, (1), 185–190.

District heating companies' efficiency of providing district heating to small houses in Finland and Sweden is studied. The method used is data envelopment analysis. The results indicate that Finnish companies, overall, are more efficient when offering district heat to small house customers. In Finland, price increases demand and impacts district heating company efficiency the most. The lower price level in Finland, compared to Sweden, might be a reflection of competition between different heating goods. In Sweden, network size and company size (large companies are more efficient in providing small houses with heat than small ones) drive the efficiency of small house district heating.

10/01981 Germany and energy security in the 2000s: rise and fall of a policy issue?

Duffield, J. S. *Energy Policy*, 2009, 37, (11), 4284–4292.

After some two decades of inattention, the issue of energy security once again moved to the top of the policy agenda in Germany in the mid-2000s. After briefly achieving renewed prominence, however, it was eclipsed in German energy policy, at least temporarily, by heightened concerns about climate change. This paper explains the re-emergence of concerns about energy insecurity in recent years as well as the reasons for their subsequent overshadowing. It describes and explains the steps that have been taken during this period to promote German energy security and analyses their adequacy. The paper identifies a number of reasons to be sceptical about how much the agreed policies will improve Germany's energy security, but it concludes that there are nevertheless good reasons to expect the issue to regain the attention of policy-makers in the future.

10/01982 Gradual reforms and the emergence of energy market in China: evidence from tests for convergence of energy prices

Ma, H. *et al. Energy Policy*, 2009, 37, (11), 4834–4850.

This study investigates the emergence of energy markets by testing for convergence of energy prices with a new dataset on energy spot prices in 35 major cities in China. Both descriptive statistics and unit root are employed to test the convergence of energy prices for each of four fuel price series. The whole study period is divided into two sub-periods in order to reconcile the gradual energy reforms. The results show the steady improvement in energy market performance in China, especially during the second sub-period, which suggests that the market appears to be playing an increasing role in determining energy prices. While panel unit root tests show energy markets are integrated in China as a whole, city-by-city univariate unit root tests suggest that there are still many regional energy markets, probably because energy reserves (especially coal) vary widely across regions. Since China's energy economy is gradually moving towards market-oriented mechanisms, the existing literature may become obsolete soon.

10/01983 Hydro reservoir handling in Norway before and after deregulation

Wolfgang, O. *et al. Energy*, 2009, 34, (10), 1642–1651.

The Norwegian Energy Act that came into force in 1991 deregulated the electricity market and removed the former obligation power companies had to supply electricity to the geographical area they were responsible for. Hence producers can supply electricity on the basis of profitability. In 2007 the Energy Act was evaluated by the government. As a part of this, a study concerning hydro reservoir handling before and after deregulation was carried out by SINTEF. Public statistics show that average hydro reservoir levels measured in per cent of reservoir capacity have been reduced after 1990. The authors have used the power-market model EMPS (EFI's Multi-area Power-market Simulator) to analyse if this reduction can be explained by natural variation in climatic variables or by structural changes that have occurred after 1990. Simulation results show that the reduced reservoir levels cannot be explained by natural variation in climatic variables. Structural changes such as increased transmission capacities can, however, explain some of the reduction. The study does not indicate that the present reservoir handling gives reservoir levels that are too low. In this paper the authors also describe the stochastic dynamic optimization problem for long-term hydropower scheduling, and explain how this problem actually is solved by the EMPS model.

10/01984 Intra- and extra-union flexibility in meeting the European Union's emission reduction targets

Tol, R. S. J. *Energy Policy*, 2009, 37, (11), 4329–4336.

The EU has proposed four flexibility mechanisms for the regulation of greenhouse gas emissions in the period 2013–2020: (1) the emissions trade scheme (ETS), a permit market between selected companies; (2) trade in non-ETS allotments between member states; (3) the clean development mechanism (CDM) to purchase offsets in developing countries; and (4) trade in CDM warrants between member states. This paper shows that aggregate abatement costs fall as flexibility increases. However, limited flexibility creates rents so that increasing flexibility raises costs in some member states. Costs are reduced more by the CDM than by non-ETS trade. The CDM warrants market reduces costs by a small amount only; market power is a real issue. However, the warrants market is obsolete in case there is non-ETS trade. The CDM leads to price convergence between the ETS and non-ETS market. There would be one price for carbon in the European Union if the proposed limits on CDM access are relaxed slightly.

10/01985 Measuring the security of external energy supply in the European Union

Le Coq, C. and Paltseva, E. *Energy Policy*, 2009, 37, (11), 4474–4481.

The security of energy supply is one of the main objectives of EU energy policy. This study introduces an index designed to evaluate the short-term risks associated with the external supply of energy to the EU member states. It combines measures of energy import diversification, political risks of the supplying country, risk associated with energy transit, and the economic impact of a supply disruption. The authors construct separate indexes for three primary energy types, oil, gas and coal, and demonstrate that member states' levels of supply risk exposure differ across energies. Most other studies of this kind provide aggregate indexes combining different types of energy. The results suggest that an aggregate approach could be misleading, at least for discussions of the short-term response to risks.

10/01986 Modelling fuel demand for different socio-economic groups

Wadud, Z. *et al. Applied Energy*, 2009, 86, (12), 2740–2749.

The fuel-demand literature provides a range of estimates of the long- and short-run price and income elasticities of gasoline demand for different countries and states. These estimates can be very useful in predicting the overall impacts of policy approaches designed to reduce fuel consumption and to address concerns of carbon emissions or energy security. However, analysis of policy options based on elasticities that are homogenous across income groups provides no information about the relative distributional burden that may be faced by different sectors of the population. Different responses to the same change in price or income are likely to occur, dependent on both travel needs and income levels. This paper estimates gasoline demand elasticities for different income quintiles in the USA to test for heterogeneity in demand response. Group wise summary consumer expenditure data for 20 years is used to derive the elasticity estimates. The results show that the elasticities do vary across groups and follow a U-pattern from the lowest to the highest income quintile. The lowest income quintile is found to have the largest price elasticity. The lowest and the highest income quintiles appear to be statistically insensitive to any changes in income. The rebound effect also follows the U-pattern, with the highest rebound observed among the wealthiest households. Rural households appear to have lower price elasticity than households in urban areas.

10/01987 Small scale biomass heating systems: standards, quality labelling and market driving factors – an EU outlook

Verma, V. K. *et al. Biomass and Bioenergy*, 2009, 33, (10), 1393–1402.

In the present study a comparative evaluation of several existing quality labels and standards for small scale biomass heating systems (BHS) and the biomass fuels they use was performed. With the introduction of pellet fuels, biomass heating technology achieved enough maturity to successfully compete with oil/gas heating devices in terms of ease of use, utilization of energy and pollutant emissions. From indoor air quality and related health risks point of view, quality labelling of both BHS and fuel they use leads to stricter emissions, efficiency and safety requirements as compared to National and EU standards. Several measures supporting this green energy market in the active countries (Sweden, Nordic countries, Germany, France and Austria) were investigated. It was found that policies and financial incentives such as the Finance Law (2005–2009) in France and Market Incentives Programme (1999–2006) in Germany are the most successful. German regulations and quality label (Blue Angel) provide the stringent quality requirements for residential BHS. In Belgium, Wallonia is the most active region for biomass energy utilization (83.5 MW for residential heating in 2007). A quality label for small scale BHS however does not yet exist. An equivalent label (Optimaz) exists for oil fired residential boilers. Emphasis has been placed upon using Optimaz as a reference and to compare with other existing quality labels. As a result, an effort had been made to move ahead in the preliminary study for development of a quality label for Belgian.

10/01988 Statistical analyses on summer energy consumption characteristics of residential buildings in some cities of China

Chen, S. *et al. Energy and Buildings*, 2010, 42, (1), 136–146.
This study analyses energy consumption characteristics and investigates the influence factors of residential energy consumption in summer in typical cities of China. The residences studied were located in seven cities of five architecture thermotechnical design zones. Questionnaire surveys revealed housing unit characteristics, household characteristics, the possession and utilization of domestic energy consuming appliances and indoor thermal environment in summer. Energy consumption analyses show that summer energy consumption amounts in different cities bear distinct regional characteristics: the household amounts of electricity use are largest in Hong Kong, and the values are smaller but still at a high level in Beijing, Shanghai and Changsha, and at the smallest level in Kunming, Harbin and Urumqi, while the difference in gas use is small among these cities. Influence factor analyses show that city locations, housing unit characteristics, the utilization of space coolers and water heaters, household characteristics, and subjective evaluation of indoor thermal environment all contribute to the residential energy consumption in summer when taking all the families in the seven cities as the sample collectivity, while detail analyses for separate cities shows each city has its own characteristics. In Shanghai, the satisfaction rate of thermal environment, the possession and operation of air conditioners and housing unit characteristics greatly affect the summer energy consumption, but the electrical fan is judged as the non-influence factor, while in Urumqi, the possession and operation of electrical fans and the categories of water heaters have remarkable effect, and the influence of housing unit characteristics is also distinct, but the number of air conditioners and their usage contribute little to energy use due to the cool climate.

10/01989 The additional benefits of setting up an energy security centre

Nagy, K. *Energy*, 2009, 34, (10), 1715–1720.
An Agreement of Cooperation was concluded in 2008 on the setting up of an Energy Security Centre amongst the Hungarian Ministry of Defence, the Ministry of Economy and Transport, the Ministry of Foreign Affairs, the National Office for Research and Technology and the Prime Minister's Office. This paper summarizes the findings for the setting up of the Centre and creating the necessary conditions required for its operation. The main idea is that qualitatively new conditions to facilitate effective problem solving to meet the demands of mankind for energy are needed. The key part of this work is the creation of the structures of a global problem-solving network. It will function as a network of energy security knowledge centres (KC). A number of KC with different specialization will be built on these structures, resulting in a global network with new synergies, which will in return foster the development of new capabilities and the emergence of new way of thinking. The paper discusses the results related to the application of a global approach to energy security and points out the necessity of regarding energy security and environmental protection as integral parts of the system.

10/01990 Will energy regulations in the Gulf States make buildings more comfortable – a scoping study of residential buildings

Radhi, H. *et al. Applied Energy*, 2009, 86, (12), 2531–2539.
This paper examines the interaction between occupant thermal comfort and envelope component regulations in the Gulf States. The country chosen for this study is the Kingdom of Bahrain, the smallest country in the Gulf region. Simulation results and comparative studies were employed to investigate the impact of the current envelope component regulations on the internal environment. The paper focuses on residential buildings and concludes that the envelope component regulations contribute positively to the internal thermal performance. Although these envelope components are not generally the primary elements that impact upon internal thermal comfort there are circumstances when the components become very warm and occupants positioned close to them will experience discomfort. This paper shows that the thermal insulation regulation makes a small impact on thermal comfort, whereas the window regulation, particularly glazing, is more influential and that for most window areas, solar impacts are generally large.

Energy conservation

10/01991 A new methodology for the design of low energy buildings

Chlela, F. *et al. Energy and Buildings*, 2009, 41, (9), 982–990.
This paper aims to set up a methodology that simplifies parametrical studies during the design process of a low energy building. The methodology is based on the design of experiments method which is a statistical method widely used in industry to perform parametric studies that reduces the required number of experiments. This method was used to perform first- and second-order metamodels for the energy demand and energy consumption of an office building called Beethoven. Three French cities were considered: Nancy (cold climate), Agen (moderate climate) and Nice (hot climate). The developed metamodels showed rather good results for the annual heating demand and final energy consumption of the building. Less accurate results were obtained for the annual cooling demand. However, the accuracy of the different metamodels was improved significantly by introducing new terms similar to the Taylor series. These new metamodels were developed by coupling several conventional designs. Afterwards, a metamodelling methodology has been developed in order to design low energy buildings. The proposed methodology starts by defining the outputs and factors to consider followed by choosing a set of random experimental points used to compute the experimental errors of the developed metamodels. The designer starts by computing a basic first order metamodel using a factorial design and then improves step by step the accuracy of the metamodels if the calculated experimental errors are considered unsatisfactory. Currently, the increase of the capabilities and complexity of building energy simulation tools could result in new difficulties during the design process of low energy buildings. The obtained metamodels in this study could be used instead of the simulation tools for computing the energy performance of the buildings and to find out optimal solutions for building envelope and HVAC systems to design low energy buildings. Furthermore, these models could provide support during the building design process for rational design decisions regarding the selection of energy-saving building components. Future works will be carried out using the developed metamodels to outline guidelines solutions for building envelope and HVAC systems in order to design low energy buildings with respect to the French climate context.

10/01992 A study on energy performance of hotel buildings in Singapore

Priyadarsini, R. *et al. Energy and Buildings*, 2009, 41, (12), 1319–1324.
This paper presents a study on energy performance of Singapore's hotel buildings. Energy consumption data and other pertinent information were collected from 29 quality hotels through a national survey. Building features and operational characteristics contributing to the variations in hotel energy performance were discussed. The annual average total energy use intensity (EUI) in these hotels is 427 kWh/m^2. Electricity and gas are used in all sampled hotels, and some hotels also use diesel to power standby generator or hot water boiler. The authors also investigated relationships between electricity consumption and number of occupied rooms in individual hotels; the weak correlations found indicate it is necessary to improve energy management when occupancy rate is low. Besides, Pearson correlations between hotel energy use intensity and possible explanatory indicators revealed that three-star hotels differ from high class establishments in energy use. Worker density and years after the last major energy retrofit were also found to be highly correlated to hotel building energy use intensity. Also discussed in this paper is the effect of weather conditions on electricity consumption of the hotels.

10/01993 Compressed air system best practice programmes: what needs to change to secure long-term energy savings for New Zealand?

Neale, J. R. and Kamp, P. J. J. *Energy Policy*, 2009, 37, (9), 3400–3408.
The establishment of a compressed air system (CAS) best practice programme is a key component of one of the initial industrial energy efficiency programmes being driven by New Zealand government ministries and agencies. In a global context this is not a new initiative in that existing programmes have been functioning in Europe and USA, yet in each of these cases the impact 10 years on has been patchy with limited long-term improvements in overall energy efficiency. The New Zealand CAS best practice programme currently under development is sponsored by the Electricity Commission (EC) and the Energy Efficiency Conservation Authority (EECA). It takes a new approach in policy direction, with variations from those used in other international programmes. A significant level of electricity levy money is to be committed to this programme and it is timely to highlight its merits and potential weaknesses, and what is required to generate long-term energy savings beyond the levels achieved by more mature overseas programmes.

10/01994 Driving for fun? Comparing the effect of fuel prices on weekday and weekend fuel consumption

Frondel, M. and Vance, C. *Energy Economics*, 2010, 32, (1), 102–109.

Focusing on individual motorists in car-owning households in Germany, this paper investigates the determinants of automobile travel, with the specific aim of quantifying the effects of fuel prices and person-level attributes on travel conducted over a 5-day week and weekend. The analysis is predicated on the notion that car use is an individual decision, albeit one that is dependent on intra-household allocation processes, thereby building on a growing body of literature that has identified the importance of socioeconomic factors such as employment status, gender, and the presence of children in determining both access to and use of the car. To capture this two-stage decision process, a two-part model was used, which consists of probit and OLS estimators, and elasticity estimates derived that incorporate both the discrete and continuous choices pertaining to car use. With fuel price elasticity estimates ranging between −0.45 and −0.50, the results suggest raising prices via fuel taxes to be a promising energy conservation and climate protection measure.

10/01995 Economic evaluation of energy saving measures in a common type of Greek building

Nikolaidis, Y. *et al. Applied Energy*, 2009, 86, (12), 2550–2559.

This paper deals with the economic analysis and evaluation of various energy-saving measures in the building sector, focusing on a domestic detached house in Greece, i.e. in a typical Mediterranean climate. In order to detect the energy-saving measures that, in addition to energy benefits, can also provide economic profits, the study examines the following measures: all kinds of insulation; upgrading of the heating system; use of thermal solar systems; upgrading of lighting; upgrading of electric appliances; upgrading of the cooling system. The economic evaluation methods used for ranking the energy-saving measures are the net present value, the internal rate of return, the savings to investment ratio and the depreciated payback period. It has been found that amongst the most effective energy-saving methods are the upgrading of lighting, the insulation of the roof of the building and the installation of an automatic temperature control system.

10/01996 Efficiency of energy recovery ventilator with various weathers and its energy saving performance in a residential apartment

Liu, J. *et al. Energy and Buildings*, 2010, 42, (1), 43–49.

The energy recovery ventilator (ERV) is an effective method, which can transfer heat and moisture from the exhaust air into the outdoor fresh air to save energy in buildings. Nowadays, the ERV has been widely used in the commercial, industrial and residential buildings in China. Its energy-saving performance depends on a lot of factors, such as the outdoor environmental conditions, the enthalpy efficiency of the exchanger, and so on. Based on the relationship among sensible heat, latent heat and enthalpy efficiency, the authors analysed the weighted coefficient equations for describing the performance of ERV in different climatic zones in China. According to China weather data, enthalpy efficiency of the exchanger mainly depends on sensible heat efficiency in winter and latent heat efficiency in summer. The energy simulations of a sample apartment in a residential building were made under different operation conditions to study the performance of ERV. The energy-saving performances of the ERV were studied with five different outdoor climatic conditions, the enthalpy efficiency, fan power consumption of ERV and fresh air change rate. To improve energy-saving performance, better efficient enthalpy exchange material and higher efficiency fans must be explored, while reasonable fresh air change rate as well as proper operation period according to local climate should also be carefully considered.

10/01997 Energetic contribution potential of building-integrated photovoltaics on airports in warm climates

Rüther, R. and Braun, P. *Solar Energy*, 2009, 83, (10), 1923–1931.

Airport buildings in sunny and warm regions present a perfect match between energy demand and solar resource availability. Airport buildings are also typically large and horizontal, isolated and free of shading, and have a great potential for the integration of solar photovoltaic (PV) systems. This study assesses the potential impact in energy demand reduction at the Florianopolis International Airport in Brazil (27°S, 48°W) with the use of building-integrated photovoltaic systems. The authors analyse the building's hourly energy consumption and solar irradiation data, to assess the match between energy demand and potential generation, and estimate the PV power necessary to supply both the total amount and fractions of the annual energy demand. The results show that the integration of PV systems on airport buildings in warm climates can supply the entire electric power consumption of an airport complex, in line with the general concept of a zero-energy building.

10/01998 Energy and exergy utilization efficiencies in the Japanese residential/commercial sectors

Kondo, K. *Energy Policy*, 2009, 37, (9), 3475–3483.

Unlike the manufacturing sector, the residential/commercial sectors of Japan struggle to meet their environmental requirements. For instance, their CO_2 emission levels have increased tremendously since 1990. This research estimates energy and 'exergy (available energy)' efficiencies in Japan's residential/commercial sectors during the period 1990–2006. Since an exergy analysis reveals 'available energy losses', it is an effective tool to achieve sustainable societies. The primary objective of this paper is to examine the potential for advancing the 'true' energy efficiency in Japan's residential/commercial sectors – by observing energy and exergy efficiency disparities. The results show large differences between the overall energy and exergy efficiencies in the residential (60.12%, 6.33%)/commercial sectors (51.78%, 5.74%) in 2006. This implies great potential for energy savings in both sectors. Furthermore, this research suggests that the residential sector may face more difficulties than the commercial sector, although the latter appears to be less energy-efficient, according to recent statistics. This is because the disparity between energy and exergy efficiencies has expanded in the residential sector since 2000. This study illustrates the importance of exergy analyses in promoting sustainable energy policies and new adaptation strategies.

10/01999 Energy consumption, energy savings, and emission analysis in Malaysian office buildings

Saidur, R. *Energy Policy*, 2009, 37, (10), 4104–4113.

This paper is concerned with the estimation of energy use in office buildings in Malaysia and with the energy use of major equipment. Energy intensity (EI) – a measure of a building's energy performance – is estimated for Malaysia and compared with a number of selected countries. Air conditioners are shown to be the major energy users (57%) in office buildings, followed by lighting (19%), lifts and pumps (18%) and other equipment (6%). It is estimated that 77,569 MWh of energy can be saved and a huge reduction of emissions achieved through the application of advance glazing, compact fluorescent lamps (CFL), insulation, housekeeping, and by raising thermostat set point temperature of air conditioners, and reducing EI. It is also estimated that a very substantial amount of energy can be saved by making use of energy-efficient motors in building systems with different motor loading percentages. Finally, it can be shown that the use of variable speed drives and energy-efficient motors leads to substantial energy savings and an enormous reduction in emissions.

10/02000 Energy saving and energy efficiency concepts for policy making

Oikonomou, V. *et al. Energy Policy*, 2009, 37, (11), 4787–4796.

Departing from the concept of rational use of energy, the paper outlines the microeconomics of end-use energy saving as a result of frugality or efficiency measures. Frugality refers to the behaviour that is aimed at energy conservation, and with efficiency the authors refer to the technical ratio between energy input and output services that can be modified with technical improvements (e.g. technology substitution). Changing behaviour from one side and technology from the other are key issues for public energy policy. This study attempts to identify the effects of parameters that determine energy-saving behaviour with the use of the microeconomic theory. The role of these parameters is crucial and can determine the outcome of energy efficiency policies; therefore policymakers should properly address them when designing policies.

10/02001 Evaluation of CCHP systems performance based on operational cost, primary energy consumption, and carbon dioxide emission by utilizing an optimal operation scheme

Cho, H. *et al. Applied Energy*, 2009, 86, (12), 2540–2549.

This paper presents an optimization of the operation of combined cooling, heating, and power (CCHP) systems for different climate conditions based on operational cost, primary energy consumption (PEC), and carbon dioxide emissions (CDE) using an optimal energy dispatch algorithm. The results for the selected cities demonstrate that in general there is not a common trend among the three optimization modes presented in this paper since optimizing one parameter may reduce or increase the other two parameters. The only cities that show reduction of PEC while also reducing the CDE are Columbus, MS; Minneapolis, MN; and Miami, FL. For these cities the operational cost always increases when compared to the reference case consisting of using a vapour/compression cycle for cooling and natural gas for heating. On the other hand, for San Francisco and Boston, CCHP systems increase the CDE. In general, if CCHP systems increase the cost of operation, as long as energy savings and reduction of emissions are guaranteed, the implementation of these systems should be considered.

10/02002 Experimental investigation of an innovative low electricity consumption air cooling system for small building application

Bakos, G. C. and Tsagas, N. F. *Energy and Buildings*, 2009, 41, (10), 1058–1062.

This paper investigates the development of a low-cost air cooling system used for small-scale applications. Its operation is based on the rational and efficient use of energy available in conventional freezers, used for purposes other than air conditioning, to cool small areas. The proposed air cooling system is applied to a small kiosk prototype (called 'periptero'), found very often in the streets of Greek cities and villages, and used to sell goods to people. The proposed air cooling system is using the low-temperature air inside the freezers to cool the air inside the kiosk and provide a more comfortable environment for the owner, particularly during the summer period.

10/02003 Influence of seasonal variations on energy-saving opportunities in a pulp mill

Persson, J. and Berntsson, T. *Energy*, 2009, 34, (10), 1705–1714.

Significant energy savings can be achieved in the pulp and paper industry through process integration. The aim of this paper was to investigate how much seasonal variations in the process influence the potential for making energy savings. The hot and warm water system in a market pulp mill has been evaluated from an energy point of view, using pinch analysis. Considerable energy-saving potential was found, 40.7 MW, of which 16.5 MW was in the form of steam savings. The steam savings represent 7% of the total steam consumption at the mill. New heat exchanger networks were redesigned using different approaches. The influence of seasonal variations was estimated from the calculated energy savings when monthly averages were used in the new heat exchanger networks. When seasonal variations were taken into account, the energy-saving opportunities fell by 2.5–5.0 MW, depending on heat exchanger network design, compared with a steady-state scenario. Consequently, 88–94% of the theoretical energy savings could be realized. An economic evaluation indicates positive earnings from investment in a new heat exchanger network when seasonal variations were taken into account, even with low prices for the extracted steam and excess heat (5 €/MWh) and with an annuity factor of 0.2.

10/02004 Methods to determine stratification efficiency of thermal energy storage processes – review and theoretical comparison

Haller, M. Y. *et al. Solar Energy*, 2009, 83, (10), 1847–1860.

This paper reviews different methods that have been proposed to characterize thermal stratification in energy storages from a theoretical point of view. Specifically, this paper focuses on the methods that can be used to determine the ability of a storage to promote and maintain stratification during charging, storing and discharging, and represent this ability with a single numerical value in terms of a stratification efficiency for a given experiment or under given boundary conditions. Existing methods for calculating stratification efficiencies have been applied to hypothetical storage processes of charging, discharging and storing, and compared with the rate of entropy production caused by mixing calculated for the same experiments. The results depict that only one of the applied methods is in qualitative agreement with the rate of entropy production, however, none of the applied methods is in agreement with the rate of entropy production and also able to distinguish between the entropy production caused by mixing and the entropy changes due to heat losses.

10/02005 Modeling energy market dynamics using discrete event system simulation

Gutiérrez-Alcaraz, G. and Sheblé, G. B. *Energy*, 2009, 34, (10), 1467–1476.

This paper proposes the use of discrete event system simulation to study the interactions among fuel and electricity markets and consumers, and the decision-making processes of fuel companies (FUELCOs), generation companies (GENCOs), and consumers in a simple artificial energy market. In reality, since markets can reach a stable equilibrium or fail, it is important to observe how they behave in a dynamic framework. The authors consider a Nash–Cournot model in which marketers are depicted as Nash–Cournot players that determine supply to meet end-use consumption. Detailed engineering considerations such as transportation network flows are omitted, because the focus is upon the selection and use of appropriate market models to provide answers to policy questions.

10/02006 Quantitative assessment of energy conservation due to public awareness campaigns using neural networks

Mahmoud, M. A. and Alajmi, A. F. *Applied Energy*, 2010, 87, (1), 220–228.

This case study aims to quantitatively assess the impact of an energy conservation campaign that was launched under the name 'Trsheed' in Kuwait in the summer of 2007. Most electric energy (EE) consumption in the summer in the country is used in air conditioning and past trends indicate a strong correlation between ambient weather conditions and energy demand. The size and attitude of the population is an important factor in this regard; Kuwait has an expatriate population that is larger than the indigent population, and whose size is closely linked to economic activities that are largely dependent on oil revenues and varies with fluctuations of oil prices. Three neural network architectures (NNs) were evaluated in terms of their ability to estimate future EE demand based on previous trends. Backpropagation neural networks were found to be most suitable for this purpose in comparison to general regression and polynomial NNs. The inputs to the NNs investigated included hourly weather condition indicators; specifically the dry-bulb temperature and relative humidity. The output of the NNs was the hourly energy demand. An analysis based on actual weather data from 2004 to 2007 was performed to gauge the impact of the energy conservation campaign in the summer of 2007. Results of a second NN analysis show that round-the-clock mean weather conditions may be used to predict total future energy demand over a period of time (daily, weekly or monthly), but future peak loads should be estimated separately using mean weather conditions during peak hours only. Savings in national energy demand, as a result of future conservation campaigns, are estimated to be more than 5% and 4% in total and peak demands, respectively.

10/02007 Recommendations for energy efficient and visually acceptable street lighting

Kostic, M. and Djokic, L. *Energy*, 2009, 34, (10), 1565–1572.

While designing new street lighting installations or dealing with reconstructions of the existing ones, lighting designers usually do not take into consideration all of the available means for energy savings and optimal performance. This paper offers a set of the most important recommendations regarding the relevant influencing factors for energy savings in street lighting, the majority of which represent the results and conclusions of original research. Recommendations which result from user needs and regard visual quality are also briefly presented. Taking all of these recommendations into account provides improvement of appearance and sense of security, as well as energy and cost savings.

17 ENERGY CONVERSION AND RECYCLING

10/02008 Catalytically upgraded landfill gas as a cost-effective alternative for fuel cells

Urban, W. *et al. Journal of Power Sources*, 2009, 193, (1), 359–366.

The potential use of landfill gas as feeding fuel for the so-called molten carbonate fuel cells (MCFC) imposes the need for new upgrading technologies in order to meet the much tougher feed gas specifications of this type of fuel cells in comparison to gas engines. Nevertheless, MCFC has slightly lower purity demands than low temperature fuel cells. This paper outlines the idea of a new catalytic purification process for landfill gas conditioning, which may be supposed to be more competitive than state-of-the-art technologies and summarizes some lab-scale results. This catalytic process transforms harmful landfill gas minor compounds into products that can be easily removed from the gas stream by a subsequent adsorption step. The optimal process temperature was found to be in the range 250–400 °C. After a catalyst screening, two materials were identified, which have the ability to remove all harmful minor compounds from landfill gas. The first material was a commercial alumina that showed a high activity towards the removal of organic silicon compounds. The alumina protects both a subsequent catalyst for the removal of other organic minor compounds and the fuel cell. Due to gradual deactivation caused by silica deposition, the activated alumina needs to be periodically replaced. The second material was a commercial VS_2O_5/TiO_2-based catalyst that exhibited a high activity for the total oxidation of a broad spectrum of other harmful organic minor compounds into a simpler compound class 'acid gases (HCl, HF and SO_2)', which can be easily removed by absorption with, e.g. alkalized alumina. The encouraging results obtained allow the scale-up of this landfill gas conditioning process to test it under real landfill gas conditions.

10/02009 Characteristics of co-combustion and kinetic study on hydrothermally treated municipal solid waste with different rank coals: a thermogravimetric analysis

Muthuraman, M. *et al. Applied Energy*, 2010, 87, (1), 141–148.

This study presents an investigation on the influence of hydrothermally treated municipal solid waste (MSW) on the co-combustion characteristics with different rank coals, i.e. Indian, Indonesian and Australian coals. MSW blends of 10%, 20%, 30% and 50% (wt.%)

with different rank coals were tested in a thermogravimetric analyser (TGA) in the temperature range from ambient to 700 °C under the heating rate of 10 °C/min. Combustion characteristics such as volatile release, ignition and burnout were studied for the blend fuel. Different ignition behaviour was observed depending on the blends composition and the coal rank. The result of this work indicates that the blending of MSW improves devolatization properties of coal. But it was found that the co-combustion characteristics of MSW and coal blend cannot be predicted only from the pyrolytic and or devolatization phenomena as the other factors such as the coal quality also plays a vital role in deciding the blends co-combustion characteristics. The TGA combustion profiles showed that the combustion characteristics of blends followed those of parent fuels in both an additive and non-additive manners. These experimental results help to understand and predict the behavior of coal and MSW blends in practical applications.

10/02010 Degradation of waste high-density polyethylene into fuel oil using basic catalyst

Jan, M. R. *et al. Fuel*, 2010, 89, (2), 474–480.

High-density polyethylene (HDPE) has been degraded thermally and catalytically using $MgCO_3$ at 450 °C into liquid fraction in a batch reactor. Different conditions like temperature, time and catalyst ratio were optimized for the maximum conversion of HDPE into liquid fraction. Catalytic degradation yielded 92% liquid fraction whereas 90% wax was obtained with thermal degradation. The composition of the liquid fraction was characterized by physicochemical properties of petroleum fuel tests. The catalytic liquid fraction consisted of high concentration of C_8–C_9, C_{13}–C_{14} and C_{17}–C_{18} hydrocarbons. The distillation data showed that 50% of the fraction has boiling point in the range of gasoline and 50% in the range of diesel oil.

10/02011 Fueling an D.I. agricultural diesel engine with waste oil biodiesel: effects over injection, combustion and engine characteristics

Radu, R. *et al. Energy Conversion and Management*, 2009, 50, (9), 2158–2166.

The paper presents the results of research concerning the use of a biodiesel-type fuel in DI diesel engines; the fuel injection system and the engine were tested. The results indicated that the injection characteristics are affected when a blend containing 50% methyl ester and 50% petrodiesel is used as fuel (injection duration, pressure wave propagation time, average injection rate, peak injection pressure). As a result, the engine characteristics are also affected, the use of the biodiesel blend leading to lower output power and torque; the lower autoignition delay and pressure wave propagation time led to changes of the cylinder pressure and heat release traces and to lower peak combustion pressures.

10/02012 Hydrothermal reforming of bio-diesel plant waste: products distribution and characterization

Onwudili, J. A. and Williams, P. T. *Fuel*, 2010, 89, (2), 501–509.

A viscous waste derived from a bio-diesel production plant, in the form of crude glycerol, was reacted under subcritical and supercritical water conditions and the product composition determined in relation to process conditions. Preliminary analysis of the original sample showed that the main constituent organic compounds were methanol (20.8 wt.%), glycerol (42.3 wt.%) and fatty acid methyl esters (33.1 wt.%). Uncatalysed reforming experiments were carried out in a 75 ml Hastelloy-C batch reactor at temperatures between 300 °C and 450 °C and pressures between 8.5 MPa and 31 MPa. Oil/wax constituted more than 62 wt.% of the reactions products. At 300 °C, the main product was a waxy material containing mainly glycerol and fatty acid methyl esters. As the temperature increased to supercritical water conditions, low viscosity oils were produced and all of the glycerol was reacted. The oils contained mainly saturated and unsaturated fatty acid esters as well as their decomposition products. The gaseous products were carbon dioxide, hydrogen and methane and lower concentrations of carbon monoxide and C_2–C_4 hydrocarbons. No char formation was observed. However, during alkaline gasification with sodium hydroxide at 380 °C, the reaction products included a gaseous effluent containing up to 90% by volume of hydrogen, in addition to oil and significant amount of whitish solid residue (soap). Sodium hydroxide influenced the production of hydrogen via water–gas shift by the removal of carbon dioxide as sodium carbonate, but also decreased oil product possibly through saponification.

10/02013 Influence of the emissions trading scheme on generation scheduling

Kockar, I. *et al. International Journal of Electrical Power & Energy Systems*, 2009, 31, (9), 465–473.

The paper investigates the effects of emissions constraints and an emissions trading scheme (ETS) on the generation scheduling outcome. ETS is a cap-and-trade market mechanism that has been introduced in European Union in order to facilitate CO_2 emissions management. This scheme gives generators certain amount of CO_2 allowances which they can use to cover emissions produced during energy generation. In a current setting, most of the allowances are given for free. However, under ETS generators also have an opportunity to buy and sell CO_2 allowances on the market. Since generation power outputs are bounded by the amount of CO_2 emissions that they are allowed to produce over time, it is becoming increasingly important for generating units to manage their allocations in the most profitable way and decide when and how much of permissions to spent to produce electricity. The method proposed here allows for modelling of this new limitation by including costs of buying and selling of CO_2 allowance in the generation scheduling procedure. It also introduces additional emissions constraints in the problem formulation. Although CO_2 permissions and energy are traded in separate markets, the proposed formulation permits analysis on how emission caps and emission market prices can influence market outcome. The method is illustrated on a five-unit system. Given examples compare: (1) a base-case when all generators have made a decision to use portions of their total free allocations that do not cause any shortfall during the investigated time period; (2) two cases when the least expensive generators' decisions on the amount of free allowances they are willing to use during the considered period are insufficient. In all cases generators also submit prices at which they expect to be able to 'top-up' or sell allowances on the market, however, only in the second and third case the 'buying' option becomes active and affects generation scheduling and total costs. In addition, the paper investigates how aggregation of emissions allowances of generators belonging to the same company can affect market clearing.

10/02014 Investment and emission control under technology and pollution externalities

Heal, G. and Tarui, N. *Resource and Energy Economics*, 2010, 32, (1), 1–14.

This paper studies incentives to develop advanced pollution abatement technology when technology may spillover across agents and pollution abatement is a public good. This was motivated by a variety of pollution control issues where solutions require the development and implementation of new pollution abatement technologies. The authors show that at the Nash equilibrium of a simultaneous-move game with R&D investment and emission abatement, whether the free rider effect prevails and under-investment and excess emissions occur depends on the degree of technology spillovers and the effect of R&D on the marginal abatement costs. There are cases in which, contrary to conventional wisdom, Nash equilibrium investments in emissions reductions exceed the first-best case.

10/02015 Multicriteria analysis to evaluate the energetic reuse of riparian vegetation

Recchia, L. *et al. Applied Energy*, 2010, 87, (1), 310–319.

The management of riparian vegetation which includes cutting operations of grass, reeds, bushes and trees, is very important to reduce hydrogeologic risk. In Tuscany, riparian biomass and residues are mainly left shredded along courses or disposed in landfills as special wastes: actually different laws prohibit that tree trunks are abandoned in areas naturally affected by flooding, because they can be moved contributing to increase the water level and to maximize the hydraulic risk of some other nearby areas. In some cases, it is also possible to store the logs in specified sites from where they can be taken and used as a fuel in fireplaces or domestic heating plants. This work studies the possibility of the reuse of riparian vegetation as biomass for energy production and evaluates benefits and drawbacks from the economical, environmental and managerial points of view. Particularly, a specific methodology has been developed for two hydrological districts of Tuscany, with different typologies and densities of vegetation. First, an estimation of biomass distribution on the land and an evaluation of annual wood availability have been carried out; then, different chains concerning harvesting operation, biomass transport, storage conditions and final utilization, have been defined and compared by a specific multicriteria analysis (MCA); finally, for the most suitable bio-energy chains the life cycle assessment (LCA) has been implemented. Results of the LCA have also permitted to validate some environmental indicators used in the MCA, as mechanization level of yards, energy efficiency of plants or transport distances. The decision-making tool developed allows to compare costs and environmental benefits of the energy use of riparian vegetation, supporting local authorities involved in energy planning: in this way it is possible to confront different alternatives to match the energy demand and meet the energy saving and sustainability issues at the lowest cost for the community. In conclusion, the most interesting bio-energy chains, based on technology of direct combustion, are those that require a limited forestry mechanization, the short transport distances and the medium sized plants. The LCA applied to these most suitable chains has also shown significant environmental benefits to promote the energetic use of riparian biomass instead of fossil fuels.

10/02016 Optimizing hydrogen production from organic wastewater treatment in batch reactors through experimental and kinetic analysis

Sharma, Y. and Li, B. *International Journal of Hydrogen Energy*, 2009, 34, (15), 6171–6180.

Anaerobic hydrogen production from organic wastewater, an emerging biotechnology to generate clean energy resources from wastewater treatment, is critical for environmental and energy sustainability. In this study, hydrogen production, biomass growth and organic substrate degradation were comprehensively examined at different levels of two critical parameters [chemical oxygen demand (COD) and pH]. Hydrogen yields had a reverse correlation with COD concentrations. The highest specific hydrogen yield (SHY) of 2.1 mole H_2/mole glucose was achieved at the lowest COD of 1 g/L and decreased to 0.7 mole H_2/mole glucose at the highest COD of 20 g/L. The pH of 5.5–6.0 was optimal for hydrogen production with the SHY of 1.6 mole H_2/mole glucose, whereas the acidic pH (4.5) and neutral pH (6.0–7.0) lowered the hydrogen yields. Under all operational conditions, acetate and butyrate were the main components in the liquid fermentation products. Additionally, a comprehensive kinetic analysis of biomass growth, substrate degradation and hydrogen production was performed. The maximum rates of microbial growth (μ_m) and substrate utilization (R_{su}) were 0.03 g biomass/g biomass/day and 0.25 g glucose/g biomass/day, respectively. The optimum pH for the rate of hydrogen production ($R_H{}^2$) and SHY were 5.89 and 5.74 respectively. Based on the kinetic analysis, the highest $R_H{}^2$ and SHY for batch-mode anaerobic hydrogen production systems were projected to be 13.7 mL/h and 2.32 mole H_2/mole glucose.

10/02017 Production of diesel-like fuel from waste engine oil by pyrolitic distillation

Arpa, O. *et al. Applied Energy*, 2010, 87, (1), 122–127.

The aim of this study is to obtain diesel-like fuel from waste lubrication engine oils by pyrolitic distillation method, which can be used in diesel engines. With this aim in mind, waste engine oil is collected in a tank, and it is purified from contaminants such as dust, heavy carbon soot, metal particles, gum-type materials and other impurities by filtering in the process prepared earlier. To investigate effects of additives known as sodium carbonate ($NaCO_3$), zeolite and lime (CaO) on density, viscosity, flash point, sulfur content, heating value and distillation temperature, the purified oil samples are blended separately with additives having mass basis of 2%, 4%, 6%, 8% and 10%. The mixed samples are exposed to pyrolitic distillation process to produce fuels to be used in engines. Thermal and physical properties of the produced fuels such as density, flash point, viscosity, sulfur content, heating value and distillation temperatures are examined. From these results, the CaO with a ratio of 2% has the highest effect on decreasing of sulfur content of the waste engine oil and on acquiring the most suitable distillation temperatures close to values of a diesel fuel. Diesel-like fuel (DLF) is obtained as 60% of the waste lubrication engine oil.

10/02018 Sustainability of bioethanol production from wheat with recycled residues as evaluated by Emergy assessment

Coppola, F. *et al. Biomass and Bioenergy*, 2009, 33, (11), 1626–1642.

An emergy assessment study of 24 bioethanol production scenarios was carried out for the comparison of bioethanol production using winter wheat grains and/or straw as feedstock and conversion technologies based on starch (first generation) and/or lignocellulose (second generation). An integrated biomass utilization system (IBUS) was used for combining the two kinds of feedstock. The crop was cultivated under four combinations of Danish soil conditions (sand or sandy loam) and crop managements (organic or conventional). For each of the production processes, two scenarios, with or without recycling of residues, were considered. Material and energy flows were assessed to evaluate the bioethanol yield, the production efficiency in terms of emergy used compared to energy produced (transformity), and the environmental load (ELR) in terms of use of non-renewable resources. These three indicators varied among the four feedstock production scenarios to the same extent as among the three different industrial production scenarios and in each case the efficiency was lower and the use of non-renewables higher for the non-recycling system. The system most efficient for production of bioethanol (lowest transformity) and with the lowest environmental load (ELR) was bioethanol produced from grains cultivated in the organic sandy loam scenario; systems with the highest transformity and ELR were bioethanol production based on straw from conventional cultivation and without recycling of residues. The IBUS concept obtained the best bioethanol production efficiency for each cultivation system but its consumption of non-renewable resources was not optimal.

10/02019 Sustainable valorization of plastic wastes for energy with environmental safety via high-temperature pyrolysis (HTP) and high-temperature steam gasification (HTSG)

Kantarelis, E. *et al. Journal of Hazardous Materials*, 2009, 167, (1–3), 675–684.

In the present study the energetic valorization of electric cable shredder residues (mixed plastics) has been investigated. Thermochemical conversion by means of high-temperature steam gasification (HTSG) and high-temperature pyrolysis (HTP) was studied. The effects of temperature and reaction time – process parameters – were investigated. Comparison of the results showed that HTSG seems a more suitable process in terms of produced syngas quality (64%, v/v and 13 MJ/Nm^3) than HTP because of higher H_2 yield and lower tar content.

10/02020 Synthetic fuel production from tea waste: characterisation of bio-oil and bio-char

Uzun, B. B. *et al. Fuel*, 2010, 89, (1), 176–184.

The pyrolysis of tea waste was studied for determining the main characteristics and quantities of liquid and solid products. Particular investigated process variables were temperature (673–973 K), heating rate (5–700 K min^{-1}) and nitrogen gas flow rate (200–800 cm^3 min^{-1}). The maximum oil and char yields are 30.4 (773 K) and 43.3% (673 K), respectively. The liquid and its aliphatic sub-fraction were characterized by elemental analysis, FT-IR, ^{1}H NMR, and GC/MS. The char was characterized with elemental analysis, SEM, BET, and FT-IR techniques. The aliphatic sub-fraction of the obtained bio-oil contains predominantly *n*-alkanes and alkenes, and branched hydrocarbons. According to the experimental results the liquid products can be used as liquid fuels, whereas the solid product seems to be not suitable for adsorption purposes, due to having low surface areas.